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THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 17 JANUARY, 1953 NUMBER 1

A SYSTEM OF AGE CLASSIFICATION FOR FIELD STUDIES OF WATERFOWL BROODS

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The following paper proposes a system of age classification of waterfowl broods based on the growth and development of hand-raised birds. The species considered are mallard, pintail, blue-winged teal, shoveller, baldpate, canvasback, redhead, and ring-necked duck.

Recent waterfowl studies of Low (1945), Earl (1950), and Yocum (1950) have grouped broods into weekly age classes. The determination of the age of a brood to a week is difficult, and in many cases impossible unless the observer has a keen familiarity with the species. None of the above writers discusses the criteria by which he aged broods, albeit obvious familiarity.

The field biologists of the United States Fish and Wildlife Service have placed observed broods into one of the three following age classes since 1947.

Class I —downy young
Class II —incompletely feathered young
Class III—completely feathered young prior to flight

This classification, in contrast to that of Low, Earl, and Yocum, is too general and may not provide information on vital points. For example, a one-day-old canvasback and a 25-day-old canvasback are both downy young. No measure of any change in average brood size throughout this time is obtained by the use of the Fish and Wildlife Service system.

It is therefore desirable to devise a system of age classification for broods which may be used accurately without extensive field experience and which also provides a sufficient number of essential age groupings.

An examination of the literature reveals a lack of information on growth and plumage development in most species of waterfowl. The growth and plumage notes obtained in this study are therefore presented. The system of brood age classification which was devised from these notes will follow.

Funds for the study were granted by the Wisconsin Alumni Research Foundation. Facilities were supplied by the Wildlife Management Institute. I am indebted to H. Albert Hochbaum, Director of Delta Waterfowl Research Station, and to Peter Ward, hatchery superintendent, for their generous assistance. Material on the pintail was gained largely through the work of Lyle K. Sowls. Appreciation is extended to Robert A. McCabe for his guidance in preparing the manuscript. I wish to thank J. J. Hickey and J. T. Emlen Jr. for their critical reading of the manuscript.

GROWTH AND PLUMAGE DEVELOPMENT

Weight and plumage notes were taken on the birds every seven days. The ducklings were obtained from artificially incubated wild eggs. Within twenty-four hours after hatching, the ducklings were placed in brooders made of apple crates with hardware cloth bottoms. One half of each crate was covered and a forty-watt bulb painted red was placed in the center of the roof. The temperature varied between 86 and 88 degrees Fahrenheit, and the relative humidity between 55 and 60 percent.

The ducklings were started on a diet of chopped hard-boiled eggs. Increasing amounts of moistened chick-starter mash were added until at one week the mixture was approximately 75 percent chick starter. Food was supplied twice daily, and fresh water was provided by mason jars inverted in saucers. Up to ten ducklings were put in one brooder. At the age of four or five days, the birds were placed in indoor pens approximately four feet wide and sixteen feet long with a steam-heated brooder at one end. The ducklings were screened to this end for two or three days, and thereafter allowed the full space. A trough, in the cement floor of each pen, was filled daily with fresh water and duckweed (*Lemna trisulca*). Each day the floor was scrubbed with a solution of potassium permanganate. At approximately four weeks of age, the birds were placed in indoor pens twice the size of the one above. From one to three weeks thereafter the birds were banded and released. This is the standard rearing technique used at Delta Waterfowl Station.

Sexes were not distinguished while taking the weight and plumage notes. The weights were taken to obtain a growth curve of the ducklings and to discover when the birds were one-quarter and one-half grown. For the latter purpose, comparisons were made with the fall data of Bellrose and Hawkins (1947). In making plumage observations, only changes which might have significance for field identification were noted.

TABLE 1.—WEIGHT RECORDS OF JUVENILE WATERFOWL
(Mean and standard deviation; sample size in parentheses)

Species	1 day	1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks
Mallard	29±3.1 (18)	66±9.7 (9)	148±14.4 (8)	288±24.6 (8)	388±46.0 (8)	453±58.4 (6)	683±46.8 (6)	
Baldpate	24±1.3 (8)	54±6.2 (8)	139±20.0 (8)	259±33.9 (8)	382±20.9 (8)	433±37.8 (5)		
Pintail	28±3.0 (15)	60±12.1 (9)	136±17.3 (7)	248±21.5 (4)	331±38.0 (4)	443±36.9 (4)	599±20.5 (4)	679±35.4 (4)
Blue-winged teal	18±1.8 (18)	34±6.7 (15)	95±26.2 (15)	151±31.7 (14)	204±31.7 (12)	276±42.5 (12)	291±31.0 (12)	
Shoveller	23±1.2 (6)	53±6.6 (6)	135±23.0 (6)	242±23.0 (6)	303±27.2 (4)	370±43.1 (2)		
Redhead	37±4.0 (17)	71±10.3 (13)	167±20.9 (12)	260±26.5 (11)	366±33.6 (11)	507±42.1 (11)	616±39.3 (11)	
Ring-necked duck	29±1.4 (8)	62±3.4 (8)	134±18.3 (8)	224±29.6 (8)	291±34.3 (8)			
Canvasback	34±4.5 (6)	62±6.7 (6)	140±16.2 (6)	249±32.4 (6)	351±32.4 (5)	451±42.5 (5)	582±23.5 (5)	

Table 2.—Feather Growth Records of Juvenile Waterfowl (in inches)

Species Feather tract	3 weeks	4 weeks	5 weeks	6 weeks
Mallard				
scapulars	¼	1–1½	2	2–3
flanks	½	1–1½	2–3	2–3
rectrices	½	1–2	3	3
secondaries	....	....	½–1	1–3
primaries	....	....	....	½–1½
Baldpate				
scapulars	½	1½	2–3	....
flanks	½–1½	1½	1–2	....
rectrices	1	2	3	....
secondaries	....	....	1–2	....
primaries	....	....	½–1	....
Pintail				
scapulars	½	1–1½	2	2–3
flanks	½	1–1½	2	2–3
rectrices	½	1–2	3	3
secondaries	....	¼	1–2	2–3
primaries	....	....	¼	2
Blue-winged teal				
scapulars	½–1	1	2–3	....
flanks	½–1	1	1–2	....
rectrices	½–1	1–2	3	....
secondaries	....	....	1–3	....
primaries	....	....	½–2	....
Shoveller				
scapulars	½–1	1½	2–3	....
flanks	½–1	1½	1–2	....
rectrices	1	2	3	....
secondaries	....	½	1–2½	....
primaries	....	....	½–1½	....
Ring-necked duck				
scapulars	....	1½	....	....
flanks	....	1½	....	....
rectrices	....	1½	....	....
secondaries	....	....	....	....
primaries	....	....	....	....
Canvasback				
scapulars	....	1–1½	1½	2–3
flanks	....	1–1½	1½	2–3
rectrices	....	1–1½	1½	3
secondaries	....	....	....	½–1½
primaries	....	....	....	¼
Redhead				
scapulars	....	1–1½	2	3
flanks	....	1–1½	2	3
rectrices	....	1	2	3
secondaries	....	....	....	1½
primaries	....	....	....	½

Within most of the species a reasonable similarity of weight and plumage development occurred between the individuals. In the blue-winged teal, however, an extremely wide divergence of both weight and plumage development took place between the individuals. For example, at the age of five weeks, some of the birds were completely feathered and weighed over 300 grams, while others, of precisely the same age, were still predominantly downy and had attained a weight of less than 230 grams. The appearance of these birds gave no true indication of their age. The vital question is, "Does this occur in the wild?"

William Kiel tells me that blue-winged teal broods frequently are apparently composed of ducklings of different ages. This could result from either a mixing of broods or the phenomenon of differential growth which we observed in the hatchery birds.

Blue-winged teal are characteristically nervous in captivity. (Ward, personal communication). In the pen the factor of dominance may come into maximum importance due to the confined conditions and concentrated feeding facilities. It is conceivable that individual differences in size and development are readily exaggerated in captive birds. We do not know with certainty if growth observed in the hatchery is the same as that in the wild, but there are no definite indications that it is not. Since hand-reared birds represent the most feasible method of studying plumage development, we must assume for the present that the growth of confined ducklings is similar to that of ducklings in the wild. Cases of wide variation between individuals of a species, such as the blue-winged teal, should be regarded with particular reservation.

Brood Age Classification

The three-group age classification of the United States Fish and Wildlife Service, whereby juvenile ducks are classed as being downy, incompletely feathered, or completely feathered prior to flight is a natural and logical system. These three age classes are predominantly distinct.

Within the first two groups, however, further divisions are evident. Downy young can be grouped into early and late stages; that is, a young downy under

SYNOPSIS OF GROWTH AND PLUMAGE DEVELOPMENT OBSERVATIONS

	Mallard (*Anas platyrhynchos*)	Baldpate (*Anas americana*)	Pintail (*Anas acuta*)	Blue-winged teal (*Anas discors*)
1 day old	Dark olive-brown to black above. Yellow patches on scapular region and rump; white area on trailing edge of wing. Dark eye line and aural patch. Undersurface sulfur yellow. Down patterns bright and distinct. (18)*	Olive brown above. Comparatively small, dull yellow patches on wing, scapular region and rump. Side of face and neck fulvous to buff. Faint, dusky stripe behind the eye. Lower breast and belly sulfur yellow. (8)	Gray with tinge of brown above. White patches on wing, scapular region and rump. Eyeline and aural patch present, though less dark than in mallard. Undersurface white. Down patterns distinct. (15)	Dark brown above with yellow patches on wings, scapular regions and rump. Yellow below. Dark eye stripe and auricular patch. Very similar to downy mallard except for smaller size. (18)
1 week	No important plumage change.	—	—	—
2 weeks	Down patterns less distinct and somewhat faded. (8)	Down slightly faded. Scapular and flank feather quills barely visible by close hand examination. Between 2 and 3 weeks, the birds are one-fourth (200 gms.) the weight of an adult female. (8)	Down patterns less distinct and notably duller. (7)	Bright yellow of underparts faded and down patterns less distinct. Feathers may be seen by close hand examination, but are not visible at arm's length. Between 2 and 3 weeks, the birds are one-fourth (123 gms.) the weight of an adult female. (15)
3 weeks	Scapular feathers, flank feathers and rectrices visible. Heinroth (1928) observed the appearance of these feathers at 23 days. Ducklings are now one-fourth (288 gms.) the weight of an adult female. (8)	Scapular feathers, flank feathers and rectrices present but covered by abundant down. It is doubtful if these feathers would be noticed in the field unless the observer were within ten visual feet. Feathers extend across the belly, but these are also hidden. (8)	Scapular feathers, flank feathers and rectrices visible. Ducklings are now one-fourth (248 gms.) the weight of an adult female. Heinroth (1928) notes that feather development is extremely rapid. (4)	Scapular feathers, flank feathers and rectrices visible. Feathering across belly in largest ducks. There is a wide variation between individuals. (14)
4 weeks	Ducklings fully feathered across belly, yet still predominantly downy. Secondaries not yet out of quills. Cheek feathers not yet prominent. (8)	Cheek feathers appearing. Patch of down from crown of head to rump. Ducklings still mainly downy. At 4 weeks the ducklings are one-half (382 gms.) the weight of an adult female. (8)	Secondaries barely visible; primaries emerging. Cheek feathers prominent. Fully feathered across belly. Predominantly feathered at 30 days. (4)	Cheek feathers noticeable. Secondaries beginning to appear from quills. Ducklings still predominantly downy. Now approximately one-half (204 gms.) the weight of an adult female. (12)
5 weeks	Scapular, flank and tail feathers well developed (see Table 2). Secondaries visible; primaries just emerging. Face well feathered. Ducklings now predominantly feathered, but down persists from nape to rump. Between 5 and 6 weeks the juveniles are one-half (518 gms.) the weight of an adult female. These observations are in accord with those of Heinroth (1928). (6)	Bent (1923) records that the young baldpate assumes its first complete plumage between the age of 4 and 5 weeks. This seems early from the observations of this study. At 5 weeks the juveniles are predominantly but not completely feathered. (5)	Speculum is becoming apparent by color in males. A prominent patch of down about 4 inches long remains on nape. Ducklings are now one-half (443 gms.) the weight of an adult female. At 40 days, the sexes are readily distinguished by transverse barring dorsally in the male, and longitudinal striping dorsally in the female. (4)	Some birds are predominantly downy; others are completely feathered. All of these birds are the same age to the day. (12)
6 weeks	A small patch of down remains on the nape, but it disappears in less than a week. Juveniles then appear completely feathered. (6)		Juveniles have the appearance of grown birds. Completely feathered except for remnants of down on neck, back, rump and wings. (4)	Bennett (1938) records that the last down disappears from the head and rump around the sixth week. (12)
7 weeks			Fully mature appearance. Two long strips of down remain on back, but are seen only by hand examination. Capable of flight.	

* Number of individuals in sample.

SYNOPSIS OF GROWTH AND PLUMAGE DEVELOPMENT OBSERVATIONS

	Shoveller (*Anas clypeata*)	Redhead (*Aythya americana*)	Ring-necked duck (*Aythya collaris*)	Canvasback (*Aythya valisineria*)
1 day old	Dark brown above with yellow patches on wing, scapular region and rump. Underparts maize yellow to ivory yellow. Side of head and neck fulvous yellow. Spatulate characteristic of bill not noticeable for several days. (6)*	Light yellow-brown above. Usual patches on wings, scapular regions and rump barely visible. Side of face and underparts canary yellow. No noticeable face markings. The downy redhead is the lightest and most uniformly colored of all North American ducks. (17)	Dark brown above with one prominent yellow patch on each wing, two on each scapular region, and one on each side of the rump. Side of head and underparts ivory yellow. No dark face markings. (8)	Sepia to buff-olive above. Yellow patches on wing, scapular region and rump. Side of head and underparts lemon yellow. Faint dusky eye line, not pronounced as in pond ducks. (6)
1 week	No important plumage changes. (6)	Down begins a slight fading to a more chamois-like color. (13)	No important plumage changes. (8)	Down slightly faded. (6)
2 weeks	Down patterns are faded and less distinct. Bill becoming noticeably large. Scapular and flank feather quills may be seen by close hand examination. Shortly after two weeks the ducklings are one-fourth (135 gms.) the weight of an adult female. (6)	Down colors distinctly paler. (12)	Down faded and patterns less distinct. Between two and three weeks the ducklings are one-fourth (179 gms.) the weight of an adult female. (8)	Down noticeably faded. Hochbaum (1944) notes a gradual fading of down from the first to the third week. (6)
3 weeks	Scapular feathers, flank feathers and rectrices noticeable. Feathered across belly. Secondaries not yet visible. (6)	Scapular and flank feathers barely discernible by close hand examination; not visible at arm's length. Shortly after three weeks of age, the ducklings are one-fourth (260 gms.) the weight of an adult female. (11)	Scapular and flank feathers seen by close hand examination; not visible at arm's length. (8)	Scapular and flank feathers barely discernible by close hand examination; not visible at arm's length. Between 3 and 4 weeks of age, the ducklings are one-fourth (300 gms.) the weight of an adult female. According to Hochbaum (1944) the juvenile feathers are obscured by down until the fourth week. (6)
4 weeks	Secondaries visible; primaries just emerging. Mainly downy; will be predominantly feathered in a few days. Between 4 and 5 weeks of age, the ducklings are one-half (336 gms.) the weight of an adult female. (4)	Scapular feathers, flank feathers and rectrices clearly visible. Feathering beginning on belly. Cheek feathers appear as prominent brown spots. Ducklings are still mainly downy. (11)	Scapular feathers, flank feathers and rectrices noticeable. Feathering across belly. Cheek feathers easily seen. Secondaries not yet visible. (8)	Scapular feathers, flank feathers and rectrices visible. Feathering beginning on belly. Cheek feathers appear as prominent brown spots. Development up to four weeks the same as that of redhead. (5)
5 weeks	Ducklings are now mainly feathered. (2)	Secondaries noticeable; primaries just emerging. Face well feathered with just a few tufts of down remaining. Long patch of down persists from nape to rump. Will be predominantly feathered in a few days. Between 5 and 6 weeks of age the ducklings are one-half (561 gms.) the weight of an adult female. (11)		Scapular regions and flanks now appear as dark patches. Face feathered with persisting tufts of down. Secondaries barely visible. Well feathered except for throat, nape, upper back, and rump (Hochbaum, 1944). Development at this age is several days behind redhead at same age. (5)
6 weeks		Down remains in patches on nape. Ducklings will be completely feathered in a few days.		Secondaries noticeable; primaries just emerging. Rectrices fully developed. Now predominantly feathered. At 6 weeks the young birds are approximately one-half (582 gms.) the weight of an adult female. (5)

* Number of individuals in sample.

one week of age can accurately be identified from an older downy between two and three weeks of age. In a similar manner, incompletely feathered young can be recognized as being in an early stage of feathering or in a late stage of feathering.

It appears possible, therefore, to elaborate upon the three fundamental groups of the Fish and Wildlife Service system and arrive at five reasonably identifiable age groups among young waterfowl. They are as follows:

Class I—Downy young
- Class Ia—Down patterns bright and distinct; ducklings small
- Class Ib—Down patterns faded and less distinct; ducklings approaching one-fourth the weight of an adult female.

Class II—Incompletely feathered young
- Class IIa—Predominantly downy; feathers patchy.
- Class IIb—Predominantly feathered; down remaining in patches.

Class III—Completely feathered young prior to flight; no down on nape; down on wings concealed by feathers.

These age classes are illustrated in Figure 1.

Any system of age classification of wild birds based on the plumage development of hand-raised birds has at least three weaknesses.

Primarily, the change from one age class to another is a gradual one which cannot be grouped into precise compartments. Fortunately, the periods of transition from one group to another seem

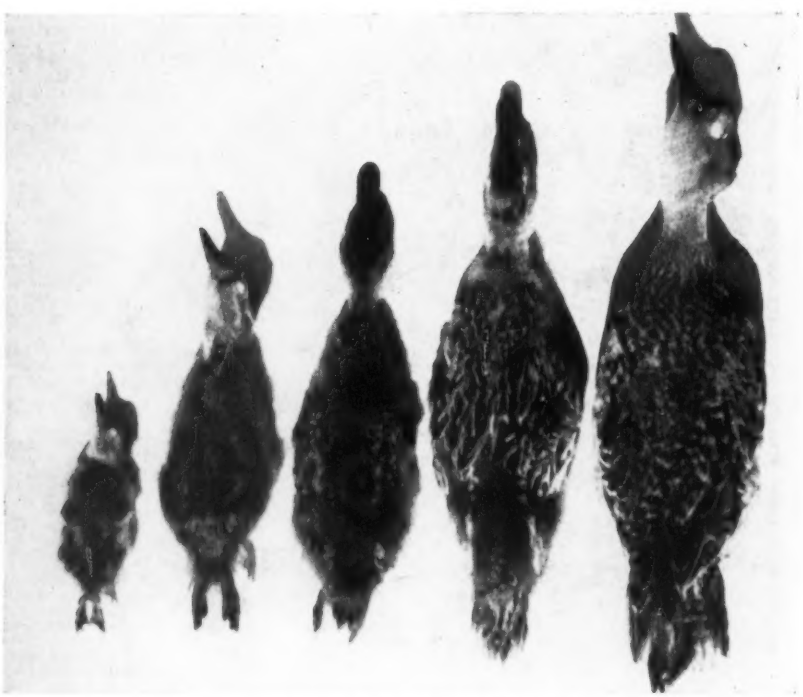

FIG. 1. Age class representatives of the pintail. From left to right: Class Ia, 3 days; Class Ib, 2 weeks; Class IIa, 3½ weeks; Class IIb, 5 weeks; Class III, 6 weeks.

to be comparatively short. The distinction between Class IIb and Class III is especially difficult, for at times the down normally present on the nape of the Class IIb individual is matted by water and the bird appears completely feathered. At best, the system requires good conditions of field observation. A preliminary trial of this classification by H. Albert Hochbaum, Lyle Sowls, and Arthur Hawkins at Delta, Manitoba in the summer of 1950 indicated that the majority of broods were readily classified. Further field use of the system is necessary before claims of its value can be made.

In the second place, individual differences in plumage development within a species may invalidate the classification in certain instances. This difficulty is partially alleviated by the fact that field brood observations deal with averages. A composite picture is obtained from all the ducklings in a brood that justifies the use of biological averages.

Finally, the classification system may be questioned because the growth of pen-reared birds cannot be equated with surety to that of wild-reared birds. This question arose in the section on growth and plumage development. H. Albert Hochbaum (personal communication) feels that a wild-reared duckling will wear off its down in less time than a pen-reared one. Thus a wild duckling would arrive at Class III slightly ahead of a captive duckling.

At the risk of exposure to these problems, the following table of chronologies is presented. Table 3 attempts to assign a time period to the age classes in each species. Future work may alter this table.

Table 3.—Age Class Chronologies. Approximate Age in Weeks When Each Species Enters the Various Age Classes

Species	Class: Ia	Ib	IIa	IIb	III
Mallard	0	1.5	3.5	5	6.5
Baldpate	0	1.5	3.5	5	6.5
Pintail	0	1.5	3	4.5	6
Blue-winged teal	0	1.5	3	4.5	6
Shoveller	0	1.5	3	4.5	6
Redhead	0	2	3.5	5.5	6.5
Ring-necked duck	0	2	3.5	5.5	...
Canvasback	0	2	3.5	5.5	6.5

Summary

This paper attempts to formulate a practical system of age classification for waterfowl broods based on a knowledge of growth and plumage development in hand-raised birds.

Although there exists much variation in weight and plumage development between the eight species studied, a similar pattern of growth may be seen. The first feathers appear on the scapular regions and flanks between the second and fourth weeks of age. The feather development proceeds mesially across the belly and up the breast. Simultaneously, the tail is developing. Feathering appears on the head about the fourth week and spreads down the neck. As this is occurring, feather growth spreads forward and backward from the center of the scapular regions. On the wings, the secondaries appear first between the fourth and fifth weeks, and the primaries emerge several days later as the body becomes predominantly feathered. The last down of the body persists on the nape and the rump. After the body has acquired complete juvenile plumage, patches of down still remain on the wing coverts.

As the ducklings become predominantly feathered, their weight is ap-

proximately one-half that of an adult female. It is seen from the weight data (Table 1) that the absolute weekly increment of weight increases after the first week. The percentage of weekly increment, however, decreases.

Five fairly discrete age classes can be identified in all species studied. They are:

Class Ia —early downy

Class Ib —late downy

Class IIa—predominantly downy with noticeable feathers

Class IIb—predominantly feathered with noticeable down

Class III—completely feathered prior to flight

A preliminary field trial of this classification has indicated that most broods can be readily placed in one of the five groups. Further critical testing in the field is needed.

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ELK MIGRATION PATTERNS, AND SOME OF THE FACTORS AFFECTING MOVEMENTS IN THE GALLATIN RIVER DRAINAGE, MONTANA [1]

Arthur R. Brazda

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Introduction

A program of tagging elk calves with plastic markers was initiated in the Gallatin Drainage, Montana in 1949 and continued in 1950 and 1951. Johnson (1951) reported the use of these markers for 1949 and 1950 in his paper on the elk calf. The writer worked with Johnson in 1950 and continued the project in 1951, when 93 calves were marked. Symbols of the same shape were used. The color combination designating 1951 was red and yellow. Thus 225 calves were marked in the 3 years. Johnson has pointed out the value of these markers for migration studies, so far as durability and visibility are concerned, but his data were too few to indicate the migration routes although he did suggest the general pattern of elk migrations. Since then, many more sight and kill records of elk marked as calves have accumulated. The present paper is an attempt to evaluate these records on the basis of movement, and to show the migration routes of the Gallatin River drainage elk herd. In addition, the writer gathered information on some factors which possibly affect elk movements. For a description of the study area see Johnson (*op. cit.*).

Thanks are extended to J. E. Gaab, Montana Fish and Game Department, for permission to use checking station records and the sight records of Norman Wortman made during the winter of 1950–51; to D. E. Johnson for the use of his 1949 and 1950 records; to Norman Wortman and J. W. Lentfer for aid in the field. Further acknowledgments are made to Dr. C. B. Philip, Microbiological Institute, Hamilton, Montana, and to Dr. J. A. Callenbach, Montana State College, for verification of the insect collections; also, to Dr. W. E. Booth, Montana State College, for verification of the plant specimens. The writer further extends his grateful thanks to Dr. Don C. Quimby, Montana State College, who directed the study.

Patterns of Elk Migrations During the Calving Period

According to Johnson (1951), the extremes of the calving periods for 1949 and 1950 were May 21 and June 12. Observations during 1951 indicated extremes of May 17 and Juné 15.

Observations of marked calves during the calving seasons for these years indicated no movement away from the calving grounds. Only 3, of 31 positively identified, had moved from the drainage where they were marked. In all in-

[1] A joint contribution from Montana State College, Agricultural Experiment Station, Project No. MS844, Paper No. 261 Journal Series and the Wildlife Restoration Division, Project 35R, Montana Fish and Game Department.

[2] Now with the Nevada Fish and Game Commission, Reno, Nevada.

stances, the movements were less than a mile and to an interlocking drainage on the calving ground. Two moved into the head of Daly Creek; 1 from the north side of the head of Black Butte Creek, the other from the south side of upper Tepee Creek. One moved from Daly Creek to Sawmill Gulch (Fig. 1). Nineteen marked on Daly Creek, 7 marked on Fan Creek, and 2 marked on Sawmill Gulch were observed in the drainage where marked. The identity of 20 marked calves seen in Daly Creek drainage was not established. In light of the behavior of the identified calves, it is probable that a high proportion of these were Daly-marked.

These data suggest that the calves remain on the calving grounds until the close of the calving season and in most instances movement is restricted to a single drainage.

SUMMER MOVEMENTS

Observations of marked calves during the period June 27 to July 31 indicated a marked movement from the calving grounds. Only 1 of 19 was seen in the drainage where marked, and it was seen on June 28. Four others seen during June, after calving season, had moved away from the drainage where tagged, but only for short distances (2.5 to 3.5 miles). From July 1 to July 15 observa-

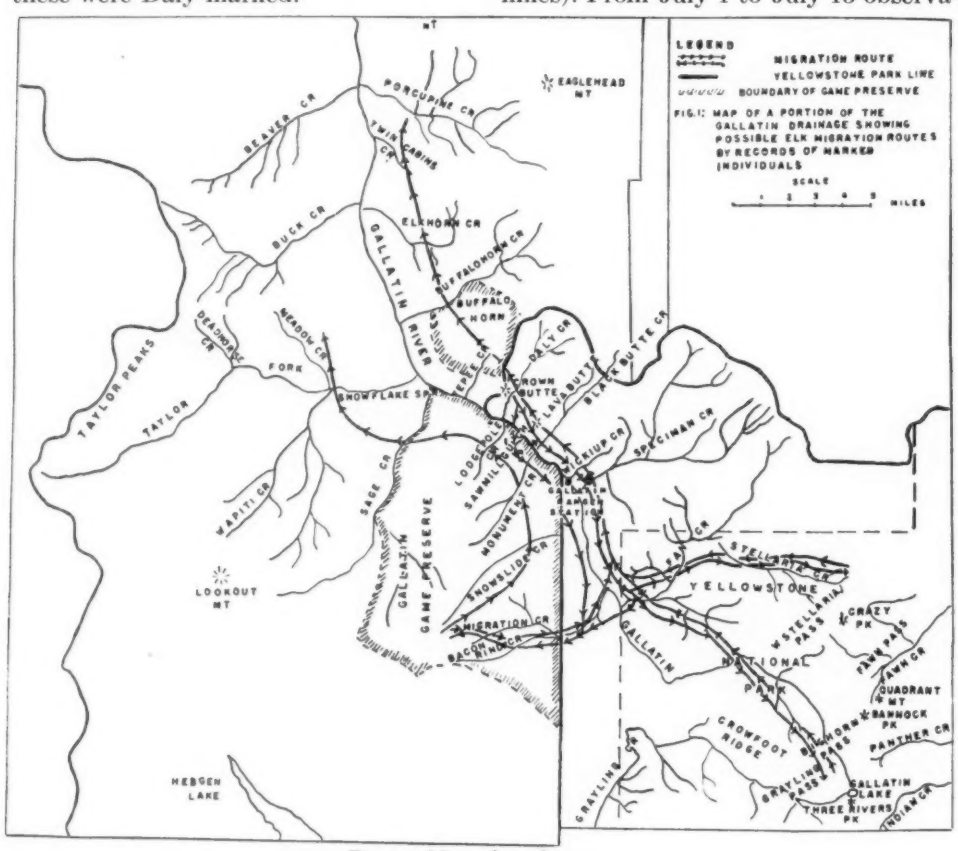

Fig 1. Map of study area.

tions of 5 marked calves showed an average movement of about 11.4 airline miles (8–18). Seven observations, July 16–31, showed an average movement of about 14.8 airline miles (6.5–18). Movements were generally to higher elevations as the season progressed.

Observations of marked calves during August indicated no movement beyond that for July, suggesting that the animals reached the limit of their migration during the latter month. Eight of 10 were seen in drainages where marked calves had been seen in July. Two, seen at the head of Stellaria Creek, represent first observations, but observations were made in the same general area at the head of the Gallatin River and on West Stellaria Pass during June and July.

Sight records of marked calves indicate summer range on both sides of the Gallatin River (vicinity of the head of the Gallatin River, Bacon Rind Creek-Migration Creek areas). Records show that calves marked on the east side of the Gallatin River may or may not summer on the same side. Of 21 seen on summer range, or enroute from the calving grounds to summer range, 15 had not crossed over and 6 had gone into the Bacon Rind Creek-Migration Creek area.

Only two sight records of calves marked on the west side of the river were obtained. Both remained on the west side, moving from Sawmill Gulch to the Bacon Rind Creek-Migration Creek area.

The pattern of the sight records provides some basis for speculating on migration routes.

Twelve Daly Creek-marked calves were seen as follows: 1, Daly Creek, June 28; 2, Fan Creek, July 11; 6, head of Gallatin River, July 13–26; 1, head of Stellaria Creek, August 2; 1, Migration Creek, August 8; 1, Bacon Rind Creek, July 15. The first 10 listed possibly suggest a migration route as follows: Daly Creek through Fan Creek to the head of the Gallatin River and vicinity. The other two do not fit into this pattern since they were seen across the Gallatin River in the Bacon Rind Creek-Migration Creek area.

Six Fan Creek-marked calves were seen as follows: 2, upper Gallatin River, June 28; 1, Fawn Pass, June 28; 1, West Stellaria Pass, June 27; 2, Migration Creek, July 18–August 16. The two upper Gallatin River observations strengthen the possibility of a migration route through Fan Creek drainage to the head of the Gallatin River, as suggested by observations of 10 Daly Creek-marked calves. The Fawn Pass and West Stellaria Pass observations could very logically be interpreted as adding further evidence in support of this possible migration route because of their proximity to the head of the Gallatin River (Fig. 1). The other 2 Fan Creek calves, like 2 of the Daly Creek calves, were seen across the Gallatin River in the Bacon Rind Creek-Migration Creek area. This gives a clue as to the route followed by the Daly Creek calves in reaching the Bacon Rind Creek-Migration Creek areas. The suggested route is Daly Creek through Fan Creek to the Bacon Rind Creek-Migration Creek area.

Two upper Gallatin River-marked calves were seen as follows: 1, Bacon Rind Creek, July 26; 1, head of Gallatin River, August 5. The first strengthens the possibility of movement across the Gallatin River to the Bacon Rind Creek-

Migration Creek area from upper Fan Creek and vicinity. The second falls into the Daly Creek-Fan Creek-head of the Gallatin River pattern.

Two Sawmill Gulch-marked calves were seen as follows: 1, Bacon Rind Creek, July 15; 1, Migration Creek, August 8. These calves could most directly reach the Bacon Rind Creek-Migration Creek area by remaining on the west side of the Gallatin River. However, there was nothing to prevent them from crossing the river into Daly Creek and moving into this area by way of Fan Creek. It follows that Daly Creek calves could cross to Sawmill Gulch and take the direct route to the Bacon Rind Creek-Migration Creek area. One example is available to substantiate this: a calf marked June 3 on Daly Creek was seen in Sawmill Gulch on June 14.

One Black Butte Creek-marked calf was seen on Migration Creek August 16. This calf could presumably take one or the other routes intimated for Daly Creek calves.

Six calves, whose marking locality is unknown, were seen as follows: 1, upper Gallatin River, June 28; 1, Grayling Pass, July 31; 3, Migration Creek, August 8–16; 1, head of Stellaria Creek, August 2.

The suggested migration routes are shown on Figure 1.

FALL MOVEMENTS

No effort was made to obtain sight records in September, 1949 and 1950. Attempts in September, 1951 were unsuccessful. The locations of 36 marked animals killed by hunters during October and November for 1950 and 1951 were secured. Of these, 15 were yearlings, and six were two-year-olds when shot.

These elk were killed in the same general areas or below the areas where they were marked as calves. The appearance of marked calves in these lower areas further indicates a considerable down country fall movement of Gallatin elk, as evidenced by sight records of marked calves in the head of the Gallatin River and Bacon Rind Creek-Migration Creek areas during July and August.

Of 29 calves marked on the east side of the Gallatin River, 24 were killed on the east side and 5 on the west side. Of 6 marked on the west side, 4 were killed on the west side and 2 on the east side. The drainage where tagged and the area of kill for the 35 animals are given below. Seventeen Daly Creek-marked calves were killed as follows: 12 Buffalo-horn Creek-Porcupine Creek area, 2 Tepee Creek, 1 Sage Creek, 1 Taylor Fork-Meadow Creek area, and 1 unknown; 6 Fan Creek calves: 4 Buffalohorn Creek-Porcupine Creek area, 1 Taylor Fork-Meadow Creek area, 1 Buck Creek; 1 upper Gallatin River calf: Daly Creek; 4 Tepee Creek calves: 3 Buffalohorn Creek-Porcupine Creek area, 1 Taylor Fork-Meadow Creek area; 1 Black Butte Creek calf: Buffalohorn Creek-Porcupine Creek area; 1 Buffalohorn Creek calf: Buffalohorn Creek-Porcupine Creek area; 4 Taylor Fork-Meadow Creek calves: 2 Taylor Fork-Meadow Creek area, 1 Indian Creek (Madison drainage), 1 Tepee Creek; 1 Sawmill Gulch calf: Taylor Fork-Meadow Creek area; 1 Lodgepole Creek calf: Tepee Creek. The first 14 Daly Creek calves, the first 4 Fan Creek calves, the upper Gallatin River calf, the first 3 Tepee Creek calves, the Black Butte Creek calf, and the Buffalohorn Creek calf possibly indicate the reversal of the

Daly Creek-Fan Creek-head of the Gallatin River migration pattern and/or the Daly Creek-Fan Creek-Bacon Rind Creek pattern noted during the upward movement.

The last 2 Daly Creek calves, the last 2 Fan Creek calves, 1 Tepee Creek calf, 3 Taylor Fork-Meadow Creek calves, and 1 Sawmill Gulch calf were killed on the west side of the Gallatin River. It is probable that these elk moved from the Bacon Rind Creek-Migration Creek area. Both sight records of calves marked on the west side of the river were in that area. Furthermore, there are sight records of Daly Creek and Fan Creek calves in the Bacon Rind Creek-Migration Creek areas.

One Taylor Fork-Meadow Creek calf and 1 Lodgepole Creek calf killed on Tepee Creek suggest the possibility that the elk intermingle somewhat after they reach the winter range. This possibility is substantiated in a later section. It is highly probable, however, that most of the elk were killed soon after leaving the sanctuary of the Gallatin Game Preserve or Yellowstone Park because of intensive hunting pressure. This suggests that the majority was killed on or near their downward migration route. The possibility of elk ranging on both sides of the Gallatin River during the winter is far greater and of much less significance than in summer. In summer most elk move to higher elevations adjacent to the river, while in winter they are generally concentrated in areas much closer to the river.

WINTER MOVEMENTS

Thirty-three sight records and one hunter kill for December, January, February, and March of 1949, 1950, and 1951 were secured. No observations were made at lower elevations than those for October and November, suggesting that the elk reached the limits of their downward movement by December. Thirteen were recorded in areas where others had been recorded in October and November: 9, Taylor Fork-Meadow Creek area (ave. 8.3 airline miles from place marked); 4, Tepee Creek (4.8). Eighteen seen at elevations above those recorded for October and November are: 3, Gallatin Ranger Station (2); 1, Upper Gallatin River (7); 1, Wickiup Creek (1.5); 3, Black Butte Creek (1); 1, Lava Butte (1); 1, Crown Butte (2); 1, Snowslide Creek (5); 2, Monument Creek (3), Sawmill Gulch (5); 2, Snowflake Springs (7.5).

These records, plus the observations recorded in the previous section, suggest that the lower limit of the winter range, on the east side of the Gallatin River, is the Buffalohorn Creek-Porcupine Creek area; on the west side, the Taylor Fork-Meadow Creek area. It is further indicated that the upper limit may extend to the mouth of Bacon Rind Creek, but is probably centered near the Gallatin Ranger Station.

Of 21 sight records, representing 12 calves marked on the east side of the Gallatin River, 10 were recorded on the east side and 11 on the west side. Of 10 records, representing 8 calves marked on the west side, 6 were observed on the west side and 4 on the east side. These data suggest that there is more intermingling of east and west side (Gallatin River) marked calves during the winter than at any other season. The probable reason for this is intimated earlier in the paper. It further suggests that east or west side marked calves are

not restricted to one side of the river on their winter range.

Three sight records have no bearing on this section; the marking locality of one was unknown, two involved animals that changed drainages (discussed in a later section).

MOVEMENTS OF INDIVIDUAL ELK

Elk seen more than once after marking, supply some basis for evaluating the migration routes indicated by the pattern of sight records.

Calf 24, marked 6/12/49 on Fan Creek, was observed 6/28/49 on Fawn Pass (Gallatin River side) and was killed 11/7/51 on Porcupine Creek. Calf 74, marked 6/8/51 on Daly Creek, was seen 8/2/51 at the head of Stellaria Creek and was killed 11/5/51 on Elkhorn Creek. These calves fit into the migration route: Daly Creek through Fan Creek to the vicinity of the head of the Gallatin River and return.

Calf 83, marked 6/1/50 on Daly Creek, was seen 7/15/50 on Bacon Rind Creek and 2/26/51 at Meadow Lake on Taylor Fork. This seemingly verifies the possibility that some of the Daly Creek elk, summering in the Bacon Rind Creek-Migration Creek area, stay on the west side of the Gallatin River in their downward movement as suggested earlier. The possibility that these elk move to the latter locality after reaching the winter range cannot be overlooked. Winter movements of calves subsequently discussed, however, seem to somewhat discredit the possibility of such a movement.

Four calves were seen as follows: calf 82, marked 5/24/50 on Black Butte Creek was seen 12/14/50 on Black Butte Creek (0 ave. airline miles from drainage marked), 1/4/51 Wickiup Creek (1.5), 1/26/51 Gallatin Ranger Station (1.5), 2/6/51 Lava Butte (1), 2/22/51 Crown Butte (2), 3/15/51 Gallatin Ranger Station (1.5); calf 118, marked 6/14/50 on Fan Creek—12/14/50 Snowflake Springs (11), 12/27/50 head of Deadhorse Creek (19), 2/20/51 Taylor Fork (13.5), 3/6/51 Taylor Fork; calf 131, marked 6/9/50 on Daly Creek—1/29/51 Lava Butte (1), 2/9/51 Gallatin Ranger Station (3); calf 135, marked 6/10/50 on Sawmill Gulch—1/26/51 Snowslide Creek (5), 2/6/51 Black Butte Creek, 2/9/51 Mouth of Monument Creek. The greatest radius of movement in airline miles for each was: calf 82 (2); 118 (4.25); 131 (1.12); 135 (1.75). These data seem to indicate that movement of elk on their winter range is restricted, although they may or may not cross the Gallatin River.

The possibility that elk return to the same winter range year after year is suggested by animals 24, 169, 171, 141, and 154. The first was killed as a two year old, the other 4 as yearlings. Data are as follows: calf 24, marked 6/12/49 on Fan Creek was observed 6/28/49 on Fawn Pass, 11/7/51 Porcupine Creek; calf 169, marked 6/6/50 on Daly Creek—1/16/51 Sawmill Gulch, 11/6/51 Buffalohorn Creek; calf 171, marked 6/6/50 on Daly Creek—12/9/50 Tepee Creek, 10/28/51 Elkhorn Creek; calf 141, marked 6/3/50 on Sawmill Gulch—2/26/51 Meadow Lake on Taylor Fork, 11/1/51 Taylor Fork; calf 154, marked 5/30/50 on Meadow Creek—12/22/50 Snowflake Springs, 10/31/51 Taylor Fork. Animals 116 and 155 indicated return to the same summer range. Both were observed as yearlings in the company of marked calves. One marked on Daly Creek, was

seen with 3 Daly Creek-marked calves. The other, marked on Fan Creek, was seen with a Black Butte calf.

Calf 32 was marked 6/3/51 on Daly Creek, and was observed 7/13/51 and 7/26/51 at the head of the Gallatin River. This strengthens the possibility that elk reach the limit of their upward movement during July as intimated earlier.

MOVEMENTS TO ANOTHER DRAINAGE

Johnson (1951), from summer observation of 12 Yellowstone-marked calves in the high country between the Yellowstone and Gallatin drainages, suggested the possibility of intermingling between the Yellowstone and Gallatin elk herds on summer ranges. Twenty-four Yellowstone-marked calves and yearlings observed in this general area in 1951, further strengthen the possibility (calves were also marked in the Yellowstone drainage in 1951, as described by Johnson for 1950).

Johnson further reports a Gallatin-marked calf as having been trapped in the Yellowstone drainage during the winter. A Yellowstone calf was seen on Gallatin winter range in December, 1950. An elk marked 6/7/50 on Fan Creek, Gallatin drainage, was killed 1/9/52 on Phelps Creek, Yellowstone drainage. These latter examples provide positive evidence of intermingling between the two herds (Table 1).

EVALUATION OF THE MARKER

Johnson (1951) reported that eight 1950 markers on hunter kills had been retained for 6 months, and only 2 were damaged. His report for 1949 markers was less favorable. Many sight records, previously discussed, during 1950–51, indicated that some of the 1950 markers were retained for as long as 18 months.

The 1951 hunting season, when 25 animals marked in 1949, 1950, or 1951 were killed, provided an opportunity to evaluate more critically the durability of markers.

Of 5 animals marked in 1949, 1 had lost the marker and ear tag; 4 had lost the marker only. These data suggest that the marker was generally torn from the ear tag. Johnson (1951) pointed out that the thin celluloid material used in

TABLE 1.—OBSERVATIONS OF YELLOWSTONE AND GALLATIN-MARKED CALVES INDICATING OR SUGGESTING INTERMINGLING OF THE TWO HERDS. LOCALITIES:— YP, YELLOWSTONE DRAINAGE; GD-FC, GALLATIN DRAINAGE-FAN CREEK; HGR, HEAD OF GALLATIN RIVER; HPC-HIC-FC, HEAD OF PANTHER CREEK-HEAD OF INDIAN CREEK-FAWN CREEK; DC, DALY CREEK; UGR, UPPER GALLATIN RIVER; MHS, MAMMOTH HOT SPRINGS; PC, PHELPS CREEK

No.	Date Marked	Locality	Dates Observed	Locality	Movements—.5 Airline Miles
8.....	1950–51	YD	6/26/51	HGR	9–13
16.....	1950–51	YD	6/29/51 8/23/51	HPC-HIC FC	9–13
1.....	1950	YD	12/12/50	GD-DC	17–23
1.....	6/12/49	GD-FD	6/28/49 1/9/50	UGR MHS	2.5 19
1.....	6/7/50	GD-FC	1/9/52	YD-PC	17

1949 was of a less durable nature than the plastic used in 1950.

Fourteen animals, marked in 1950, were killed during this period. Three had lost both the marker and ear tag. Three markers were returned in perfect condition. Eight were broken when received. Two were broken, but not enough to destroy their legibility. Six had at least 1/5 of the marker broken off. All could be identified in the hand, but some could not have been recognized at a distance. Hunters who turned in broken markers were solicited to determine whether markers were broken at the time of kill. The results were as follows: 2 had been broken after time of kill, 4 were broken before the time of kill (includes the 2 slightly damaged), and for 2, no further information was obtained. These data substantiate the possibility of marker damage after the time of kill as suggested by Johnson (1951). It further indicates, that when heavy material was used, the ear tag had to be torn from the ear before the marker was lost.

The plastic material used for the 1951 markers was of two thicknesses; .67 and 1.07 mm. Six 1951 marked animals were killed. Four markers of the heavier material were recorded as follows: one was in perfect condition; two were reported by hunters as having been in perfect condition at the time of kill; condition of the other is unknown. One marker of the lighter material had been lost, and one was verified as having been in perfect condition at the time of kill. These data strengthen the possibility of considerable marker damage after the time of kill. This is also suggested by broken markers with clean breaks. It further indicates the value of durable material.

FACTORS INFLUENCING ELK MOVEMENTS

Horseflies (Tabanidae)

The effect of tabanid flies on red deer (*Cervus elaphus*) movements in Scotland has been discussed by Darling (1937). The emergence of the smaller tabanids during the early spring season provoked the deer into moving into the high country before the vegetation had developed. Early in the fly season, the deer came to lower elevations during the night to feed, but later, as the larger flies emerged, they went high to stay for the remainder of the season. Here they occupied well winded areas and came down only during periods of rainfall when the flies were inactive. Tabanid activity reached its peak about the middle of hot, sunshine days, usually ceasing around 6:00 p.m.

Johnson (1951) suggested that insect infestations were a major nuisance to elk during July and August in the Gallatin drainage. During this period, elk occupied the high, windy ridges as much as possible. Rush (1932) and Murie (1951) further attribute considerable annoyance to flies.

An attempt was made to evaluate the effect of tabanid flies on elk movements. It was necessary to devise a method for sampling the tabanid population. Since the writer accomplished the field work on horseback, it seemed logical to use the horse as a "collecting agent" to measure the relative abundance of tabanids in a given place at a given time. Then it was necessary to determine whether tabanids that molested horses were the same species as those that molested elk. Collections were made from horses and a captive elk in the

same general area in the Gallatin drainage. The results are listed in Table 2.

TABLE 2.—SPECIES OF INSECTS COLLECTED FROM HORSES AND ELK IN 1950 AND 1951

Species	Horse	Elk	
	1951	1950	1951
Hybomitra rhombica osburni	59	4	31
Hybomitra sonomensis	19	1	..
Hybomitra rupestris	16	..	3
Hybomitra frontalis septentrionalis	13	..	..
Hybomitra opaca	8	..	..
Hybomitra tetrica hirtula	7	1	1
Hybomitra affinis	3	..	..
Chrysops furcata	4	1	..
Chrysops noctifera pertinax	3	..	..
Glaucops fratellus	3	..	..
Atylotus incisuralis	1	..	..
*Symphoromyia atripes**	5	..	..
*Symphoromyia hirta**	1	..	..
*Haematobia serrata**	5	1	11
*Muscina assimilis**	4	..	..

* Blood sucking insects not tabanids.

Five species were collected from the elk. All were included in collections from the horses. This seemed to justify the use of a horse for measuring tabanid population that would molest elk. Four species of blood sucking flies, other than tabanids, were found on horses, one of which was also found on the elk.

A method was devised to show a tabanid population index for a given area: to observers, one on each side of the horse, counted the flies which hovered near or landed on the horse during a ten minute period. The total number was then divided by 2 to get an average which was used as an index of the population. Counts were made as near the middle of the day as possible, when tabanid activity was supposedly at its peak. An attempt was made to correlate the index with elk numbers in that area.

Evidently the emergence of tabanids did not affect the upward movement of elk from the winter range because no tabanids were seen on the summer range until July 13, after the elk had moved into these areas.

To determine the effect on daily movements, counts were made at low and high elevations in the same area of the summer range during the fly season (July 13 to August 21). If possible, the counts were made in areas recently vacated by elk to get counts as near to elk as possible.

Count 1 was made 7/15/51 at 2:30 p.m., in the high country on Grayling Pass. No tabanids were observed, and 110 elk were recorded. In comparison count 2 was made 1 hour later down low in a moist, open meadow along Grayling Creek. A high population index of 55 was recorded, and no elk were seen in the area.

Count 3, made low along the Gallatin River at 11:00 a.m., 7/26/51, had an index of 28. No elk were seen. This count was compared with counts 4 and 5 made on the same day, in the adjacent high country. Count 4, 2:30 p.m., had an index figure of 6 and 305 elk were recorded; count 5, 5:00 p.m., recorded an index figure of 7.5, and 134 elk were observed.

Counts 6, 7, and 8, 8/1/51, were made down low on Grayling Creek in different areas within a half-mile radius. Count 6, 11:30 a.m., recorded an index of 7 and no elk were observed. The low index was possibly due to the short, hard rain which fell early that morning. (According to C. B. Philip, personal communication, tabanids are inactive after a rainstorm). Count 7, 12:50 p.m., had an index of 25 which was much higher than count 6 possibly because of the later time allowing for more drying after the rain. No elk were recorded, but evidence

of 40 beds indicated that elk had been there early in the morning about the time of the rainstorm. This is in accordance with Darling's observations that the red deer came down low during rainy weather when the flies were inactive. Count 8, 2:15 p.m., had an index of 119 and no elk were observed. This count was made approximately 100 yards within the timber.

Count 9, 8/2/51, 12:25 p.m., was made in a moist, open park at medium elevation. The population index was 59.5, and 15 elk were seen in the area. At the exact time this count was made, 251 elk were observed bedded down on a high, breezy adjacent slope.

Count 10, 8/15/51, 2:30 p.m., was made in a high, well drained basin. The index recorded was 12.5, and 2 elk were recorded.

Four counts, at high elevations, had low population index figures, and recorded elk in each case. Four counts, at low elevations, in the same general area, recorded high index counts and no elk. One low index was recorded at a low elevation, but this was probably due to a rainstorm before the time of the count. A high population index was recorded at a medium elevation with 15 elk in the area. These data indicate an inverse relationship between tabanids and elk numbers suggesting movements of the elk away from the infested areas.

The last tabanids recorded in this general area were on August 21. This suggests that the flies had no effect on the downward movement of the elk, as elk were seen in the area as late as September 18.

DEVELOPMENT OF VEGETATION

Murie (1951) reports that many Jackson Hole elk follow the snowline back to the summer range, leaving areas where the new vegetation is well developed to go to high areas where the vegetation is scarce, possibly suggesting a higher palatability in the newest vegetation. Darling (1937) states that the red deer (*Cervus elaphus*) make definite journeys to certain areas in quest of certain species of vegetation.

In this study, an attempt was made to show the relationship between elk movement and vegetation development. Plants were collected at random throughout the upper winter and summer ranges from May 23 through September 26, 1951. They were pressed, identified, and classified as to the stage of development: succulent-no flowers evident; succulent-flowers developing or developed; succulent or curing-flowers mature or degenerating, in or beginning to seed. The complete list of plants collected is reported in the author's unpublished thesis at Montana State College.

During the periods when plant collections were made, all elk seen in the general area were recorded as an index of the population (Table 3).

An attempt was made to determine the choice of plants of feeding elk by direct observations similar to that of Cowan (1945). It was necessary, however, to examine the plants closely to determine those utilized.

During the calving season, when large numbers of cows remained on the upper winter range, the vegetation was in early stages of development. The average number of elk seen per day was somewhat consistent suggesting little or no movement from this general area at this time (this discussion chiefly concerns cows since only 47 of 1699 elk

TABLE 3.—NUMBERS AND PERCENTAGES OF PLANTS COLLECTED IN EACH DEVELOPMENTAL CATEGORY AND AVERAGE NUMBER OF ELK SEEN, BY PERIODS

(Number in parenthesis following number of elk indicates number of observations)

UPPER WINTER RANGE

	5/23–5/29	5/30–6/5	6/6–6/12	6/13–6/20
A* stage	18(43%)	5(45%)	9(60%)	8(38%)
FD stage	24(57%)	6(55%)	6(40%)	13(62%)
FM stage	0	0	0	0
Ave. No. Elk seen	76(5)	124(3)	71(4)	94(7)

SUMMER RANGE

	6/26–7/2	7/11–7/17	7/25–7/31	8/1–8/7	8/8–8/14	8/15–8/21	8/22–8/28	8/29–9/4	9/5–9/11	9/12–9/18	9/19–9/26
A* stage	7(13%)	4(7%)	5(8%)	0	1(1%)	0	0	0	0	0	0
FD stage	43(83%)	50(89%)	55(90%)	29(97%)	72(80%)	41(54%)	24(49%)	5(24%)	2(8%)	0	0
FM stage	2(4%)	2(4%)	1(2%)	1(3%)	17(19%)	35(46%)	25(51%)	16(72%)	24(92%)	20(100%)	4(100%)
Ave. No. Elk seen	60(6)	206(5)	371(3)	301(2)	34(2)	69(3)	61(2)	0(2)	0(1)	2(3)	25(2)

*A stage is succulent, no flower evident.
FD stage is succulent, with flower at least developing.
FM stage is succulent or curing, flower maturing or degenerating, in or beginning to seed.

recorded were classified as bulls). This might lead one to suspect that the cows remained in this area because of the abundant new succulent vegetation, but other evidence would not support this. For one thing, the mature bulls apparently moved to higher areas during this period, as evidenced by their absence in daily counts and the evidence of elk migrations to higher areas (migration trails through snowdrifts). Rush (1932) states that the cows and newborn calves are the last to leave the winter range. Furthermore, the vegetation was clearly in a later stage of development on the summer range when large numbers of elk began to appear there.

Unfortunately, no observations were made on the summer range for 6 days following the calving season. During the first week, 6/26/51–7/2/51, of operations on the summer range, an average of 60 elk was recorded for 6 observations. Thirteen percent of the plants collected were in the succulent-no flower evident stage, A; 83% were in the succulent-flowers developing or developed stage, FD; 4% were in the succulent or curing-flowers mature or degenerating, in or beginning to seed stage, FM. In the second period of observation, 7/11/51–7/17/51, an average of 206 elk were recorded for 5 counts: 7% of the plants collected were in the A stage, 89% in the FD stage, 4% in the FM stage. During the third period, 7/25/51–7/31/51, an average 371 elk was recorded for 3 counts: 8% of the plants collected were in the A stage, 90% in the FD stage, 2% in the FM stage. In the fourth period, 8/1/51–8/7/51, two counts gave an average of 301 elk: none of the plants collected was in the A stage, 97% were in the FD stage, 3% in the FM stage. These data seem to indicate that the majority of the elk did not move into the high summer range until many of the plants were well developed. The fact that the elk moved onto the summer range in early July is

discussed previously in migration studies. It is possible that the cows would have moved to the summer range when the vegetation was in an earlier stage of development, had this not been the period for parturition. This seems logical because the bulls apparently moved to higher elevations before the cows. Obviously, the cows are retarded in their migration by calving duties. Newborn calves are definitely limited in their ability to move. Johnson (1951) reports that calves do little moving until the third or fourth day after birth. Observations in this study suggest that they are not capable of extended movements until they are much older. One calf, 3 or 4 days old, remained with 6 moving cows for about 300 yards, then lay down in a game trail and made no attempt to run when approached. A calf, marked at the age of 1 day, was found 3 days later, approximately 75 yards from the place marked. One, marked at 1 day, was found 4 days later, about 400 yards from the marking locality. A calf, marked at 7 days, was found a day later; it had moved about 75 feet. One marked at 3 days was found 10 days later in almost the same location. Another, marked at 8 days, was found 5 days later, approximately 1/4 mile from the place marked. Even after the calves of certain cows in the herd are capable of long movements, it does not follow that these cows move before others in the herd, because of the gregarious nature of elk. On June 20, 1951, two groups, one of 20 cows and 20 calves, and another of 50 cows and 25 calves, were observed.

Feeding observations indicated that the elk fed on a wide variety of plants in various stages of development. Plants that were grazed during the spring and/or summer are listed below by groups in order of preference, determined by their frequency in grazing observations. The grasses and sedges taken were as follows: *Carex nubicola* (Cloud Sedge), *Carex raynoldsii* (Raynolds Sedge), *Poa epilis* (Skyline Bluegrass), *Phleum alpinum* (Alpine Timoth), *Festuca ovina* (Sheep Fescue), *Festuca idahoensis* (Idaho Fescue), *Poa secunda* (Sandbergs Bluegrass), 2 unidentified *Poa* spp.

The forbs taken most often were *Agoseris glauca* (Pale Agoseris), *Trifolium rydbergi* (Rydberg Clover), and *Trifolium Haydeni* (Hayden Clover). The next 3 in preference were *Lupinus sericeus* (Hairy Lupine), *Delphinium stachydeum* (Tall Mountain Larkspur), and *Rumex paucifolius* (Slender Meadow Dock). Those recorded the fewest times were *Taraxacum officinale* (Dandelion), *Viola nuttallii* (Violet), *Ranunculus glaberrimus* (Buttercup), *Aquilegia flavescens* (Columbine), *Balsamorhiza saggitata* (Arrowleaf Balsamroot), *Heracleum lanatum* (Cow Parsnip), and 1 *Ranunculus* sp. Arrowleaf Balsamroot and Cow Parsnip were taken readily during August in local areas on the high summer range. No observations of elk actually taking these two species were made, but elk were recorded throughout the areas in question, and only their sign was observed around the grazed plants.

Of 11 plant species, recorded as grazed on the upper winter range, from May 23 through June 20, 1951, 9 were in the A stage of development, and 2 were in the FD stage. The percentages for the two stages in relation to total plant development, indicate that the FD stage was

more prominent during this period (Table 3).

Fourteen species grazed from 6/26/51–8/7/51, showed the following: 5 were in the A stage; 10 in the FD stage. One species was grazed in both stages. In this period, the FD stage was by far the most evident on a total plant percentage basis (Table 3).

Nine species grazed from 8/8/51–9/26/51, indicated the following development: 1 in the A stage; 4 in the FD stage; 6 in the FM stage. Two were grazed in both FD and FM stages. The percentages, in relation to total plant stages, show that the FM stage increased throughout the period.

These data seem to indicate that the elk showed a preference for the species in the A stage while on the upper winter range. This could possibly be due to the fact that most of the species grazed were recorded only in the A stage during this period (7 out of 11). The possibility that the elk moved to higher areas to feed on the new vegetation is not borne out in the next period. The FD stage of development was most evident per species grazed. Parturition may have been an important factor in determining the time of this movement.

SNOWCOVER

The possibility that snowcover was a factor in retarding the upward movement of the elk during the spring of 1951, was not apparent. Elk marking operations were initiated May 22 on Fan Creek. Snowcover was negligible, with the open areas having only an occasional small patch of snow. The open area bordering both forks of Fan Creek (Fig. 1) was practically devoid of snow.

On June 7, a trip up the Gallatin River to within about 4 miles of the head of the river, revealed no snow except in small localized areas on timbered slopes. High, open parks on the summer range were observed, with very little snow evident.

Snow conditions on Daly Creek were nonexistent throughout the period from May 23 through June 20 except for an occasional patch encountered during the first week of operations.

SUMMARY

1. The marking of elk calves with plastic ear markers, initiated in 1949 and 1950, was continued in 1951 in the Gallatin River Drainage, Montana. Ninety-three were marked in 1951, making a total of 225 for the three years.

2. Sight and kill records of marked individuals provided the basis for a study of elk migration patterns.

3. Observations of marked calves on the calving grounds (upper winter range), indicated no movement away from this area until the close of the calving season. Only 3 of 31 positively identified, had moved from the drainage where marked. In all instances, movements were less than a mile, and to an interlocking drainage on the calving grounds.

4. Observations of marked calves, from June 27 to July 31, indicated movements to generally higher elevations as the season progressed. Four of five marked animals observed in June, after the calving season, had moved away from the drainage where marked, but only for short distances (2.5 to 3.5 airline miles). From July 1 to July 15, 5 sight records indicated an average movement of 11.4 airline miles. Seven observations, July 16–31, showing an

average movement of about 14.8 airline miles. Eight of 10 marked animals seen in August were seen in drainages where marked animals had been seen in July, suggesting that the animals reached the limit of their migration during July.

5. Sight records of calves marked on the east side of the river, indicated summer range on both sides: head of the Gallatin River area and the Bacon Rind Creek-Migration Creek area. Fifteen of 21 had remained on the east side; 6 had crossed over. Two calves marked on the west side, remained on the west side (Sawmill Gulch to the Bacon Rind Creek-Migration Creek area).

6. The pattern of sight records suggested the following migration routes: Daly Creek through Fan Creek to the head of the Gallatin River; Daly Creek through Fan Creek to the Bacon Rind Creek-Migration Creek area; Daly Creek through Sawmill Gulch to the Bacon Rind Creek-Migration Creek area; Sawmill Gulch to the Bacon Rind Creek-Migration Creek area; Sawmill Gulch through Daly Creek through Fan Creek to the Bacon Rind Creek-Migration Creek area.

7. Fall movements are indicated by 35 hunter kills near or below the marking localities. Twenty-four suggested a reversal of the Daly Creek-Fan Creek-head of the Gallatin River migration pattern and/or the Daly Creek-Fan Creek - Bacon Rind Creek - Migration Creek pattern. Nine suggested a movement from the Bacon Rind Creek-Migration Creek area down the west side of the river. Two suggested the possibility that the elk intermingle somewhat after reaching the winter range.

8. Thirty-four winter records suggested that the elk reached the limits of the downward migration by December. No observations were made below those for October and November.

9. Data suggested that the lower limits of the winter range, were the Buffalohorn Creek-Porcupine Creek area and the Taylor Fork-Meadow Creek area. The upper limit may extend to the mouth of Bacon Rind Creek, but is probably centered near the Gallatin Ranger Station.

10. Thirty-one sight records, representing 20 calves, suggested considerable intermingling of east and west side (Gallatin River) animals during the winter.

11. Movements of the individual elk seen more than once, substantiated the migration routes intimated by the pattern of sight records.

12. Observations of 4 marked calves indicated restricted movement on the winter range, though they may or may not cross the Gallatin River.

13. Records of 5 animals, suggested that some elk return to the same winter range year after year; two suggested return to the same summer range.

14. Thirty-six Yellowstone drainage-marked animals were observed on the same summer range as that used by Gallatin drainage elk. Five of the Yellowstone animals were seen with Gallatin-marked elk. These data suggested intermingling of the two herds on the summer range. Positive evidence is indicated by the following records: 2 Gallatin-marked animals recorded in the Yellowstone drainage during January; 1 Yellowstone animal observed during December in the Gallatin drainage.

15. Plastic marker returns from hunter kills in 1951, indicated much better results when heavy, durable material was used. Two thicknesses, .67 and 1.07

mm., of plastic material were used in 1951. Some of the markers were retained in perfect condition for 18 months. Verification by hunters who had turned in broken markers, substantiated the possibility of marker damage after the time of kill.

16. A study of tabanid populations for certain localities on the summer range, indicated an inverse relationship between tabanid numbers and elk numbers.

17. Plants collected throughout the upper winter range, during the calving period when large number of elk were present, indicated that the vegetation was in an early stage of development. Later collections from the summer range, during the period when large numbers of elk began to appear there, indicated the vegetation in a later state of development. This suggested that the period of parturition was more important in governing the upward movement of cows than plant development.

18. Species of vegetation grazed were determined by careful examination of an exact area in which the elk had been feeding. Twenty-two were recorded: 9 grasses and sedges; 13 forbs. *Carex nubicola* (Cloud Sedge), and *Carex raynoldsii* (Raynolds Sedge) were recorded most often.

19. Snowcover was apparently not a factor in retarding the upward movement of the elk during the spring of 1951.

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THE EFFECTS OF STREPTOMYCIN AGAINST SPONTANEOUS QUAIL DISEASE IN BOBWHITES *

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Quail disease or ulcerative enteritis is primarily a disease of birds in confinement. The principal changes from the disease occur in the intestine, and are ulcerative in nature. This is the basis for the synonym "ulcerative enteritis" for the disease. In acute cases death may occur within one day after exposure without the development of the striking intestinal lesions. In cases of longer standing the birds become listless, lose weight, and droop with ruffled feathers. Then the typical internal picture is one of intestinal hemorrhages with later development of ulcers often perforating with resulting adhesions and peritonitis. The die-off continues until a large majority of the flock is lost. Any survivors are potential carriers and contaminated equipment is a hazard to future use.

No promising treatments were known until recently when it was shown that a concentration of 15 grams of streptomycin "base" [1] per gallon of water given for 5 to 10 days to quail 9 weeks of age resulted in a marked deterrent effect on the development of experimental ulcerative enteritis (Kirkpatrick *et al*, 1951). Later the same investigators showed that 1.75 grams of streptomycin "base" per gallon, given as late as 2 days post-exposure and continued for 5 days suppressed the expectable course of enteritis in confined quail. This was the minimum treatment tried against a massive exposing dose by hand, and nearly complete to complete suppression resulted when 5 to 15 grams per gallon were used, and when 1 gram per gallon was given from the day of hatching (Kirkpatrick *et al*, 1952a). In a subsequent test it was shown that when streptomycin mixture, a product available from streptomycin manufacture, was added to the mash ration in quantities of 0.1%–1% by weight (30–300 mgs. of "base" per lb.) that complete protection is conferred to quail against even the symptoms of the disease following massive exposure (Kirkpatrick *et al*, 1952b). In each test 87–95% of unmedicated controls died. In these studies the several concentrations of antibiotic in the water and feed were each tested with groups of 20–25 birds, maintained in metal cages with ½-inch mesh wire floors which were carefully steam-cleaned before each trial. The results demonstrated what might be expected from the use of the antibiotic under controlled conditions and when the antibiotic could be applied either in anticipation of or shortly after exposure. An opportunity to study the effect of streptomycin where the spontaneous disease was present on a large scale soon occurred.

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[1] Streptomycin Merck (Calcium Chloride Complex) Veterinary, generously supplied for this work by Merck and Co., Inc., Rahway, New Jersey.

MATERIALS AND METHODS

From March 14 to March 22, 1951 a large game farm in Indiana was losing an average of 41 adult quail per day. All dead birds posted showed definite lesions of enteritis. Pure streptomycin base in drinking water was given from March 23 to April 10 inclusive. On the first day the concentration was 5 grams per gallon, and 1 gram per gallon on following days. Treatment was given right down the several long lines of coops (each holding up to 25 birds) in the field, omitting every sixth coop for the untreated comparison. The only variable was the medication in the water, given to the treated coops only. A daily record was kept of mortality from treated and untreated coops.

Another trial involved the use of more than 3200 newly hatched quail chicks. On July 31, a total of 1219 quail were started on a mash diet containing 0.1% streptomycin mixture. At the same time 2017 quail were started on the same basic ration without antibiotic added. Details of management were the same in both groups which comprised 8 brooder houses. The only variable was the antibiotic added to the mash fed to the treated group. The young quail were transferred to field coops, each holding 25 birds, on September 14 after which the treatment was continued until November 4.

RESULTS

In case of the adult quail flock where the quail disease was rapidly spreading, the administration of streptomycin in the drinking water definitely changed the course of events as shown in Table 1.

In case of the young quail, part of which were receiving the fortified mash, about 15.5% of each of the two groups had been lost before September 14. Losses were largely due to accidents with enteritis unknown in the brooders. The uniform mortality for both groups also indicates freedom of disease. Upon transfer to the field coops at about 6 weeks of age the young quail were housed in coops in the areas of previous disease experience, and by chance were or were not immediately exposed to old contaminations. However, the history of disease in the coops was of long standing and it seems highly improbable that any coop could be free of the causative organisms. The losses for a 7 week period following transfer are shown in Table 2.

TABLE 1.—SUMMARY OF MORTALITY IN ADULT QUAIL BEFORE AND DURING TREATMENT

Deaths prior to treatment (March 14–22)	328
Deaths during treatment (March 23–April 10)	142
In 21 untreated coops	70
In 106 treated coops	72
Untreated bird loss during treatment, 70/327	21.4%
Treated bird loss during treatment, 72/1656	4.3%

TABLE 2.—MORTALITY LOSSES IN TWO GROUPS OF GROWING QUAIL, SEPT. 14–NOV. 4

	Total Birds	Deaths	Percent of Loss
Treated	813	17	2.0
Untreated	1366	230	16.8

All dead birds posted from the untreated group showed definite lesions of enteritis. Not all birds dying from the treated group were secured for posting, but those examined were negative.

DISCUSSION

There is no doubt of the effectiveness of these materials in a controlled experi-

ment in which individually exposed birds received equal amounts of inoculum simultaneously. The lethality of the inoculum was shown by 87–95% mortality in the untreated controls, while the ability of the antibiotic to abort symptoms of the disease was evident when given in the drinking water to 424 exposed quail with a mortality of only 21% for all levels of treatment. In 19 groups of 20–25 quail thus treated, survival was 100% in five groups, and 90–96% in three other groups. As a remedial agent for use early after exposure it was clear that streptomycin "base" in water had definite therapeutic value against quail disease. The question as to its treatment value in a spontaneous "field" epidemic remained unanswered.

The conditions of sanitation and routine management common to large or small scale game rearing operations are conducive to ever present opportunities for spread of infection so that the operator never knows just when or where the disease may strike. The causative organism is presumably bacterial in nature (Morley and Wetmore, 1936) transmitted through the droppings. Consumed either as fresh excrement or as residual contaminant from previous occupants of the coop, the total consumption in either case, even in successive daily increments, would not in all probability approach the 1 cc. amount given by hand directly into the crops of the experimental birds. Further, the time of natural exposure may not be uniform throughout the flock. Some birds would be exposed before others, perhaps some not at all. On the basis of these considerations, it seemed that good results might obtain when a portion of the afflicted bobwhites were treated with the aqueous solution of streptomycin.

For the period of treatment under field conditions the difference in mortality between treated and untreated birds is dramatic (Table 1) and is strong evidence that even when enteritis is rampant in the breeding flock the simple administration of streptomycin in water will reduce mortality to 20% of what can be expected in untreated birds. The value of birds theoretically saved by the medication is of interest. In 1951 adult bobwhites were priced at $5.00 per pair. If the 1656 birds had not been treated, it is possible that 21.4% or 354 of their number would also have succumbed, instead of the 72 after treatment. The value of the possible loss was $\frac{354-72}{2} \times \$5 = \$705$. Streptomycin "base" wholesales for 60¢ per gram. The total cost of treatment of the 1656 birds for 19 days was 369 grams × 60¢ = $221.40. Thus the net savings appears to have been $483.60.

Quail disease seems particularly virulent among flocks of young quail during late summer. As a prophylactic for growing birds that might come into contact with contaminated surroundings, the earlier experimental evidence showed that either of two methods of administration were of value. These were the provision of 1 gram of streptomycin "base" per gallon of water daily from the day of hatching, and the provision at the minimum level of 0.1% by weight of a streptomycin mixture in the mash ration. In either case birds so treated were unharmed by doses of infectious material lethal for the controls (Kirkpatrick *et al*, 1952 a,b). Although at the time of the second field test, the strepto-

mycin mixture was available only on an experimental basis, its administration in the mash was chosen for convenience in handling.

The results (Table 2) indicate the high degree of protection under natural conditions of exposure and compare favorably with the high rate of survival obtained when birds were manually exposed. Thus it appears that great benefits are obtained by the use of streptomycin under a variety of conditions, with all ages of quail, and when used either as a preventive or a remedy. Streptomycin is the only material shown to have a beneficial effect in preventing or suppressing the symptoms of enteritis in quail. The material can be given as a routine practice. Its occasional use as need arises does not eliminate the need for improving sanitation wherever possible to prevent recurrences of the disease, and for early recognition of recurrences in order to obtain the most benefit from additional courses of treatment. Streptomycin treatment of experimentally exposed quail apparently interferes with the development of resistance in survivors to subsequent exposure, although survivors of the spontaneous disease are resistant to experimental exposure (Kirkpatrick *et al*, 1951).

Quail disease or ulcerative enteritis has not been discovered among wild quail, but the disease has been reported in a wild ruffed grouse in Minnesota (Bump *et al*, 1947). Ordinarily the disease is a plague to quail raisers (Bass, 1939) and under conditions of confinement it also attacks western quail, grouse, wild turkey, and chukars (Shillinger and Morley, 1937; Bump *et al*, 1947). Only slim evidence exists that carriers may exist in the wild populations, but the possibility should not be ruled out, particularly since the malady has repeated opportunities for introduction via game farm stock.

Although this report deals only with a study of confined birds, it is not to be construed as an argument for maintaining artificial game rearing for the purpose of large scale restocking programs for which voluminous evidence indicates little success (Buechner, 1950). Nonetheless the principle of game rearing is not without virtue. At least some of the successful establishments of pheasants, chukar partridge, and perhaps Hungarian partridge in North America must be attributed to this activity. Furthermore pen-reared birds are useful research material as shown by contributions to the knowledge of grouse and quail biology (Bump *et al*, 1947; Nestler, 1949; Baldini *et al*, 1952). Further fundamental studies in laboratory and field are possible with the use of artificially reared birds.

Of late, new interest has been aroused concerning exotic game introductions (Bump, 1951), hearkening back to a step taken even prior to multiplication of such introductions under wire. Rare species will perhaps continue as subjects for artificial methods of increase (Smith, 1952) and with good cause where most natural obstacles can be overcome except disease occasioned by confinement itself.

According to Buechner's summary the initial cost of quail production is in many cases prohibitive. In our experience it seems probable that the high production costs may be partly attributable to quail disease among both adult and growing birds. At least where birds

are being grown or held for experimental purposes, economy of the operation is a primary consideration. Therefore, it is felt that since streptomycin has very dramatic effects in both preventing and stopping the ravages of enteritis among pen-reared quail, and since it is the only substance readily available on the market known to have these qualities, the results of game farm tests would be of general interest. Investigators should also be aware of the growing family of antibiotics and alert to the possible opportunities for application in the study of certain other wild animals' diseases particularly as such diseases might affect animals in confinement for experimental or justifiable propagation purposes.

SUMMARY

When streptomycin in drinking water was given to adult game farm bobwhites in which serious losses to enteritis were occurring, the losses among the treated quail during a treatment period of 19 days were 4.3% while losses among the untreated birds were 21.4%. When a large number of newly hatched quail were fed a mash fortified with streptomycin mixture, and a similar group fed mash without the antibiotic, the percent mortality due to enteritis among the untreated group was more than 8 times that among the treated birds. These observations were made under game farm conditions and demonstrate the benefits of using streptomycin when quail disease is a threat to stock confined for any purpose.

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SEX AND AGE STUDIES IN FALL-SHOT WOODCOCK (*PHILOHELA MINOR*) FROM SOUTHERN WISCONSIN

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Combined sex and age ratios of fall-shot woodcock have not been published because of the uncertain methods of recognizing sex and age in the fall. Mendall and Aldous (1943), Pettingill (1936) and Tufts (1940) all noted the larger size of female woodcock. Tufts indicated that the length of the bill was a good but not conclusive sex criterion, and Mendall and Aldous concurred. There are no published records of age ratios obtained by the bursa of Fabricius method; in fact Petrides (1950) indicated that probing the bursa of the woodcock from the cloaca apparently is not possible. In recent studies I have obtained some evidence that the possibilities of accurately determining the sex and age of woodcock by external examination have not been exhausted.

This study of sex and age in woodcock was begun by Aldo Leopold in 1944. I joined him in 1945 and have continued the study since his death in 1948. I am indebted to Dr. R. A. McCabe of the Department of Wildlife Management, University of Wisconsin, for encouragement and advice. The data were derived from examination of 209 woodcock shot by the staff and students of the Departments of Wildlife Management and Zoology at the University of Wisconsin from 1946 through 1951. Most of the birds were shot in central and southern Wisconsin and a few were from southeastern Wisconsin. The majority were obtained in the latter half of October. Measurements of weight, bill length and tensile strength, tenth-primary-feather length and width (2 cm. from the tip), center-toe length and central-tail-feather length were taken. No single measurement was taken on all of the 209 birds. The extent of skull ossification was examined in six birds. Internal observations were made of the bursa of Fabricius, the gonads and oviduct. In all cases I attempted to probe the bursa of Fabricius from the cloaca and checked the results internally thereafter.

Results

The differences between the sexes found in this study were the same as those found by Mendall and Aldous (*op. cit.*) and Tufts (*op. cit.*) with one addition: the width of the outer three primary feathers was greater in females than in males. The average width of the outermost primary of 26 males was 2.8 mm. and of 29 females 3.9 mm. In only five of these was there any overlap. Figure 1 shows the tenth-primary wing feathers from birds of known sex. The difference between the two is discernible even without measurement.

The bursa of Fabricius has been widely used to determine the age of gallinaceous birds (Gower, 1939). I checked the presence or absence of the bursa of Fabricius by dissection in 209 woodcock. The basal width of the oviduct was the only measurement obtained, either external or internal, which

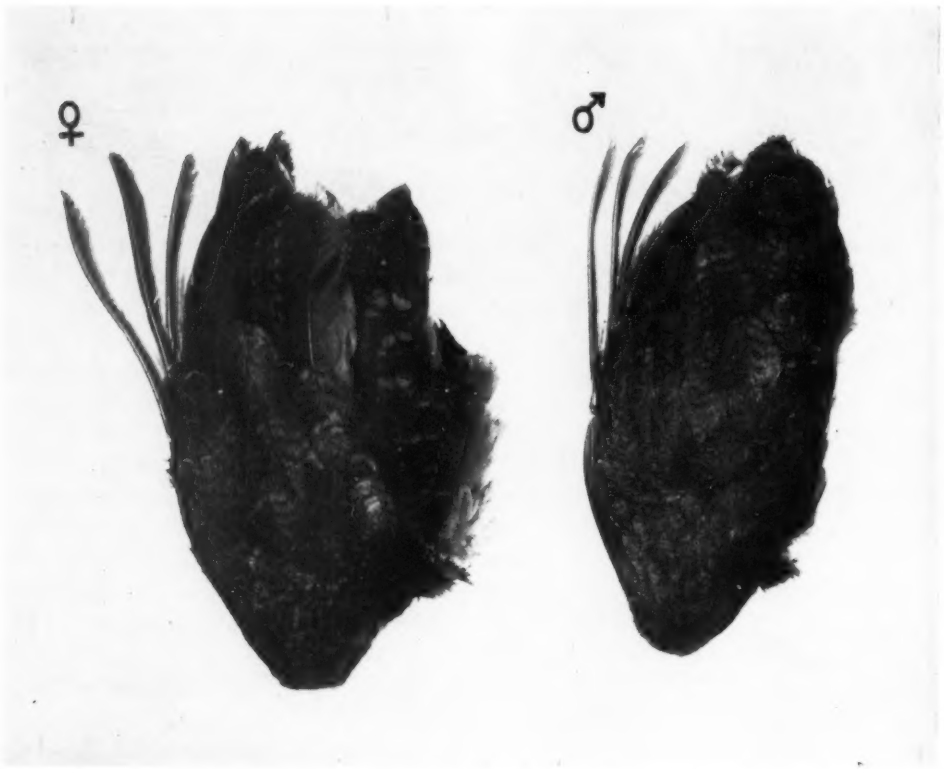

FIG. 1. Wings of male and female woodcock showing the wider outer primary feathers of the female.

could be correlated with the presence or absence of the bursa. Of 58 female woodcock having bursae, the basal diameter of the oviduct was not more than 1 mm., while 55 females having no bursae had a basal oviduct diameter of 3 mm. or more. Three females with no bursae had the small oviduct.

Early attempts at probing the bursa from the cloaca made by Leopold and myself proved difficult due to the small size of the vent. For this reason we cut the lateral edges of the vent with scissors to enlarge the opening. Ultimately I found it simplest to tear apart the antero-ventral lip of the cloaca with the fingers. In this way both sides of the cloaca could be rolled back so that the entire inner surface was exposed. Even with this improvement it was several years before I was able to locate the bursal canal with regularity. In 1951, 79 per cent of 43 birds were correctly aged in this way. The technique offers promise.

Weights and bill lengths are shown by sex, age and season in Table 1. Bill lengths were measured from the base of the nares to the tip of the bill rather than as the length of the culmen. Hence, the measurements are somewhat shorter than those reported by other authors. In this study weight and bill lengths are greater in females than in males as noted

TABLE 1.—WEIGHTS (GMS.) AND BILL LENGTHS (MM.) OF WOODCOCK BY SEX, AGE AND SEASON

	JUVENILE				ADULT			
	♂♂		♀♀		♂♂		♀♀	
Date	Mean Wt. ±S.E.*	No.	Mean Wt. ±S.E.	No.	Mean Wt. ±S.E.	No.	Mean Wt. ±S.E.	No.
Oct. 1–15.....	165±4.3	4	201±3.4	9	164±4.8	12	196±3.5	15
Oct. 16–31.....	170±1.7	32	214±2.8	38	170±1.6	33	215±2.1	42
Totals.....	169±2.1	36	212±2.4	47	168±1.8	45	209±2.1	57
	Mean Bill Length ±S.E.	No.	Mean Bill Length ±S.E.	No.	Mean Bill Length ±S.E.	No.	Mean Bill Length ±S.E.	No.
Oct. 1–15.....	62±2.0	3	67±1.0	5	62±1.0	7	70±0.5	8
Oct. 16–31.....	62±0.5	22	68±0.5	28	61±0.5	22	67±0.6	32
Totals.....	62±0.5	25	68±0.5	33	61±0.5	29	68±0.5	40

* Standard error of the mean.

by Mendall and Aldous (*op. cit.*) and Tufts (*op. cit.*). There is a slight gain in weight from the first half to the last half of October shown by both sexes and both age groups. This is probably due to deposition of fat. The weight and bill measurements are the same in both age groups indicating that young woodcock have reached their full growth by October. Thus, these measurements cannot be used to distinguish juveniles from adults.

DISCUSSION

The primary-feather-width method of sexing woodcock is a useful addition to the previously known methods. It makes possible compilation of a sex ratio from wings sent in by hunters and will help increase the accuracy of sexing woodcock by external methods. I calculated from the data of Tufts (*op. cit.*) and Mendall and Aldous (*op. cit.*) that sex could not be distinguished by bill length alone in about 16 per cent of the birds. Of the 55 birds in which the outer primary was measured, only 9 per cent overlapped. Determination of the sex of 106 woodcock by gross examination of the outer *three* primaries resulted in only 3 errors.

While age determination by examination of the cloaca for presence or absence of the bursa of Fabricius is difficult in woodcock, the use of the bursa is still valid in October. The larger size of the oviduct in females without bursa undoubtedly is an indication of previous breeding activity. It has been observed that the oviduct of chickens does not return to its prelaying size in inactive adults (Buckner *et al.*, 1925).

The sex and age ratios obtained in this study are too limited to be useful when broken down year by year. A summary of all the years is shown in Table 2.

The sex ratio of 80 males:100 females is not a significant departure from a 1:1 ratio but is in general agreement with other available figures. Tufts (*op. cit.*) found 90 males:100 females in 205 birds from Nova Scotia; Mendall and Aldous

TABLE 2.—SEX AND AGE RATIOS OF FALL-SHOT WOODCOCK FROM SOUTHERN WISCONSIN 1946–1951

	No. Males	No. Females	Males : 100 Females
Juveniles.....	42	50	84
Adults.....	51	66	79
Totals.....	93	116	80

(*op. cit.*) found 75 males:100 females in 609 birds from Maine, and I found the same ratio from 35 wings sent in by Wisconsin hunters in the fall of 1951. I found no figures available to compare with the age ratio of 1.4 young per adult female. Lack (1943) published a life table based on returns from European woodcock (*Scolopax rusticola*) banded as young. From this I have calculated an age ratio in the bag of 2.6 young per adult female or roughly double what I have found in the American species.

In summary, 209 woodcock were examined for sex and age. One new sex difference, the broader outer primary feather of females, was found. The absence of the bursa of Fabricius in October was taken as a valid indicator of adulthood because previous breeding history of females was indicated in these birds by oviducts which were larger than those found in females with bursae. While the technique needs improvement, I believe the presence or absence of the bursa of Fabricius can be accurately determined by probing from the cloaca.

The sex ratio of 209 birds, determined by examination of the gonads was about 80 males:100 females in both adults and young. The age ratio of these birds, determined by dissection of the bursa, was 1.4 young per adult female. Females of both ages were heavier than males and had longer bills, but the two ages were alike in these measurements.

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AMMATE IN THE DIET OF DEER

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The die-off in the deer herd in the Choccolocco Game Management Area of the Talladega National Forest during the summer of 1949 attracted attention both from game authorities and the general public. Because the die-off coincided with a period when Ammate (ammonium sulfamate) was used by the U. S. Forest Service to kill certain trees on the area, circumstantial evidence indicated this chemical may have been responsible for the mortality. Ammate was used in the forest from June 28 to August 15. It was applied to oaks and other broad-leaved species of trees for the purpose of timber stand improvement.

Application was made by chopping one or more notched "cups" in tree trunks at a height of about 1½ or 2 feet above the ground, and then applying about a dessert-spoonful of Ammate into each cup-shaped wound. A tree 10 to 12 inches in diameter at breast height usually had three or four "cups" chopped out and treated. In the earlier part of the period when Ammate was applied, sap was flowing freely in the trees. At that time sap combined with the Ammate to form a gummy, and salty-tasting paste. This paste was reported to have been absorbed by the tree within 6 or 8 hours after application.

It was in the third week after "poisoning" was begun that most of the dead deer were found. On the basis of a field survey, it is estimated that as many as 600 deer may have died in the area, which includes approximately 20,000 acres of good deer habitat and a greater acreage considered to be "fair." Most of the mortality was concentrated near streams in the best deer habitat.

A residue "having the properties of ammonium sulfamate" was recovered from the intestines of two deer found dead on the area. This discovery by the State Toxicologist added to the belief of many that Ammate was responsible for the die-off.

The possibility was considered that Ammate might become poisonous to deer when combined with sap in twigs and leaves of a plant being killed. There was also a possibility that Ammate might stimulate growth and make palatable certain poisonous plants which normally are not eaten in sufficient quantities to be toxic. A search of the literature failed to yield any data that indicated whether or not Ammate is poisonous to large animals such as deer or cattle. Two publications dealing with tests on toxicity to rodents have appeared. As a result of the die-off and a lack of published information, experiments to determine the possible effect of Ammate on deer were initiated.

Procedure:

Facilities for study consisted of two pens and three doe deer. One of the

[1] Sponsored by the Alabama Polytechnic Institute, State Department of Conservation, U. S. Fish and Wildlife Service, and the Wildlife Management Institute.

animals was adult and two were yearlings at the time of the experiments with crystalline Ammate, post oak and sweet gum in 1950. In each test at least one deer was used as a check animal. Feeding experiments were carried on during two summers. Species of plants, treated with Ammate and fed to the deer included some of those most commonly treated in timber stand improvement. Approximately a 2-week interval was allowed between tests, during which "rest period" the deer were fed corn, sweet cow feed, and alfalfa hay. These foods were also available to deer fed crystalline Ammate and Ammate-treated sweet gum and post oak. The animals on test diets of Ammate-treated water oak, persimmon, and black cherry received nothing in addition except water and rock salt.

Trees used in testing were generally less than 6 inches in diameter at breast height. They were treated by applying the Ammate in one or two V-shaped cuts in the bark. Most of the trees so treated usually began wilting in 2 or 3 days. As soon as the foliage showed a marked degree of wilting or discoloration, the small terminal branches with leaves were cut and brought to the deer pens for feeding. In most cases, the samples were cut between 4 and 7 days after the Ammate was applied. Freshly cut foliage was provided daily. One pen of deer received the wilted Ammate-treated foliage, the deer in the second pen served as a check and received freshly cut untreated foliage of the same species.

Free Choice of Crystalline Ammate:

Crystalline Ammate was placed in the pen with two yearling does from June 20 to July 24, 1950. Because the Ammate sample gained in weight from 315 grams to 607 grams during this period, as a result of its hygroscopic qualities, the amount consumed was not learned. However, a yearling doe was observed eating Ammate on three separate days. No salt of any kind had been given the animals for approximately a month previous to this experiment.

At no time during the experiment did either of the deer to which crystalline Ammate was available show any signs of illness or loss of condition. In fact, one deer gained $13\frac{1}{2}$ pounds and the other $7\frac{1}{2}$ pounds. These yearlings were still growing at the time and could be expected to gain in weight. The check animal, a mature doe, showed no significant change in weight during the same period.

In a test performed at the Alabama Polytechnic Institute Veterinary School, two calves to which Ammate was made available on a free-choice basis along with calf meal and hay for one week were not affected. As far as could be determined, they consumed Ammate according to a personal communication from J. F. Hokanson, 1951. Hokanson then force-fed one ounce of Ammate to one calf and two ounces to a second calf each day for 10 days. He states "no harmful effects were noticed, in fact, the calves seemed to improve in appetite and in quality of their condition. . . . No change in the blood count or in appearance of the blood picture was noted."

Sweet Gum Diet:

The deer on the experimental diet of sweet gum (*Liquidambar styraciflua*) were provided with branchlets and leaves of this species for a period of 14 days. Two yearling does were fed foliage

from saplings whose leaves were wilting from the effects of Ammate. A mature doe was fed untreated foliage.

Sweet gum foliage wilting from the effects of Ammate produced no symptoms of sickness and did not cause any loss of condition. In fact the two yearling does gained $2\frac{1}{2}$ and 1 pounds, respectively. The old deer on the check diet showed no change in weight.

Post Oak Diet:

Post Oak (*Quercus stellata*) foliage was fed to three deer for 15 days. Foliage wilting from Ammate was fed two yearling does. Freshly cut, untreated foliage was provided a third animal, an old doe.

None of the deer was found to suffer any ill effects from the diet. Each of the two animals on a diet of Ammate-treated post oak gained weight, one adding $1\frac{1}{4}$ pounds, and the other 2 pounds. The old doe on a check diet of untreated foliage lost $3\frac{3}{4}$ pounds during the diet test.

Water Oak Diet:

A diet consisting exclusively of water oak (*Quercus nigra*) was maintained for a period of 14 days. Foliage wilting from Ammate was fed two adult does. Freshly cut untreated foliage was provided a third adult doe used as a check. Of the two animals on the Ammate-treated diet, one lost 7 pounds and the second $2\frac{1}{2}$ pounds. A loss of $10\frac{1}{2}$ pounds was registered by the check animal feeding on untreated foliage. No sign of discomfort or illness was noted.

Persimmon Diet:

Persimmon (*Diospyros virginiana*) foliage wilting from the effect of Ammate was fed to an adult doe for a period of 14 days. Two check animals (adult) were provided untreated foliage. The deer receiving Ammate-treated foliage showed no change in weight, but of the two check animals on the untreated foliage, one registered a loss of one-half and the other $11\frac{1}{4}$ pounds.

Black Cherry Diet:

Wild black cherry (*Prunus serotina*) foliage was fed to three adult deer for a period of 14 days. The animal on a diet of wilting Ammate-treated cherry foliage lost $4\frac{1}{2}$ pounds. Losses of 11 and $12\frac{1}{2}$ pounds were experienced by the two adult does on the freshly cut untreated cherry foliage. No sign of sickness was noted.

DISCUSSION

Experimental feeding of crystalline Ammate to three captive deer did not result in any apparent discomfort or illness to the animals. In fact, the deer to which the Ammate was available gained in weight during the test. Calves receiving doses of crystalline Ammate also gained in general condition (J. F. Hokanson, personal communication, 1951).

Deer that were fed diets of foliage from Ammate-treated sweet gum and post oak plus a portion of sweet cow feed gained in weight. This gain is believed to have occurred mainly as a result of continued growth of the still immature yearling animals.

The experimental diets of foliage from water oak, persimmon and black cherry were maintained without the availability of other food except rock salt. Results indicate that each of these three species is in itself inadequate as food for deer. Although each of the animals on the water oak, persimmon, and black cherry

diets lost weight, it is pointed out that in each case the animal or animals on the Ammate-treated foliage lost less weight than those on freshly cut untreated foliage of the same species.

The experimental feeding of black cherry was conducted last because it was feared the animals would die from "cherry poisoning." Wild black cherry, when consumed, is one of several cyanogenic plants that commonly results in death to sheep and cattle because of the liberation of hydrocyanic acid.

Although the three deer ate leaves, buds, and twigs of the black cherry for 2 weeks, they suffered no ill effect except continued loss of weight. This loss also occurred on diets of persimmon and water oak. In general, there was a gradual decline of weight during each of the three diet tests when no other food was available. One of the animals lost some weight between experiments when it was on a regular diet of corn, sweet cow feed, and hay. The animal was near death from starvation when the tests were concluded.

SUMMARY

Deer that were provided Ammate in crystalline form or were fed Ammate-treated foliage of sweet gum, post oak, water oak, persimmon, and black cherry were found to suffer no ill effects from the diet. Results indicate that the use of Ammate in weeding out trees does not endanger deer.

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GAMEBIRD WEIGHTS

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Expanding activity in the wildlife field during the past two decades has been accompanied by a marked increase in gamebird weight records deposited in the files of the U. S. Fish and Wildlife Service. At present there are nearly 26,000 such records.

Reports on weighings of waterfowl and upland gamebirds have been received from cooperators throughout the

country—mainly from bird banders and from investigators checking the contents of game bags. Thus, many of the records, particularly of Canada geese, mallards, and some other waterfowl, represent live weights while many others are from birds shot during the hunting season. Besides innumerable contributions from individuals or from state Pittman-Robertson programs, some of the listings large and others small, additional information from literature and unpublished reports has been used. For waterfowl, use has been made of weight data in Francis H. Kortright's "Ducks, Geese and Swans of North America," published by the American Wildlife Institute (1942).

In the tabulations which follow, eighty species of gamebirds are listed in systematic order, together with their average and maximum weights (latter omitted in a few instances). Minimum normal weights are difficult to ascertain accurately because of complications from disease or other abnormalities. Commonly, however, there is about as much deviation below the average as there is above. Not all of the eighty species listed are gamebirds in the strict sense. For example, no open season is allowed at present on either species of swan, on Ross's goose, or on the ground dove.

Though the total of nearly 26,000 weight records is large, the data for some gamebirds, such as rails and certain quail, are scant. Furthermore, even the species with large or moderately large numbers of weighings are generally represented inadequately from various parts of their range. In the case of the bobwhite, however, sufficient records are available to denote clearly that there is a progressive increase in weight from south northward. Whereas bobwhites in Florida average about 5.7 ounces, specimens from Wisconsin average a full ounce heavier (6.8 ounces).

If any weight summations are made in the future, it would be desirable to have more rigid standards for eligibility of records than was possible in the present one. By obtaining greater uniformity in details of weighing procedure, avoidable variables can be reduced or eliminated. The kind and quality of scales used is an important factor. So are the units or fractions-of-units of weight reported. An unusual quantity of food in the crop might make the difference between an average-weight specimen and a heavy bird or might cause a heavy individual to become an all-time heavyweight record. Loss of blood and wetness of plumage also are details not to be overlooked.

Eventually, as weight data improve in quality and increase in quantity, they may have greater value in management programs. As standards of weight become better established within different regions, deviations from the average will be increasingly significant by indicating abnormal conditions such as disease and malnutrition. Weight may then serve as an important criterion in evaluating suitability of local environment for wildlife.

In the following tables of data, bargraphs are used to denote average weight of males and females. Weight data are expressed in pounds and by a broad bar in the case of heavier birds such as waterfowl, grouse, pheasant and wild turkey. Data for other lighter species are recorded in ounces and with a narrower bar.

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TABLE 1.—WEIGHTS OF GAME BIRDS

SWANS, GEESE, AND BRANT

No. of Birds	Sex	Average Weight Graph; 1/10 Inch = 1 Lb. (0 5 10 15 20 25 30)	Av. Lbs.	Max. Lbs.
Whistling Swan				
35	M		15.8	18.6
42	F		13.6	18.3
		(An unsexed specimen recorded at 21 lbs.)		
Trumpeter Swan				
7	M		27.9	38.0
4	F		22.6	24.5

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 5 10)	Av. Lbs.	Max. Lbs.
Common Canada Goose				
232	M		8.4	13.8
159	F		7.3	13.0
(Unsexed bird recorded at 22 lbs.)				
Western Canada Goose				
9	M		10.2	12.5
6	F		7.8	9.5
Lesser Canada Goose				
113	M		5.9	10.5
129	F		5.6	8.5
Hutchins's Goose				
31	M		4.5	6.0
37	F		4.1	5.2
(An unsexed bird recorded at 6.3 lbs.)				
Cackling Goose				
30	M		4.4	5.6
20	F		3.0	5.1
American Brant				
19	M		3.4	4.0
14	F		2.8	3.9
Black Brant				
26	M		3.4	4.9
15	F		3.1	3.6

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 5 10)	Av. Lbs.	Max. Lbs.
Barnacle Goose				
3	M		4.2	4.4
3	F		2.5	2.6
Emperor Goose				
7	M		6.2	6.8
9	F		6.1	6.9
White-fronted Goose				
22	M		5.3	7.3
18	F		4.9	6.3
Tule Goose				
21	M		6.6	7.5
13	F		5.6	6.5
Lesser Snow Goose				
22	M		5.3	6.8
32	F		4.8	5.6
Greater Snow Goose				
21	M		7.3	10.4
13	F		6.2	6.5
Blue Goose				
16	M		5.4	6.5
13	F		4.8	6.3
Ross's Goose				
18	M		2.9	3.6
21	F		2.7	3.4

TABLE 1. (*Cont.*)

DUCKS

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 … 5)	Av. Lbs.	Max. Lbs.
Common Mallard				
3963	M		2.7	4.0
3169	F		2.3	3.6
Black Duck				
366	M		2.7	3.8
297	F		2.4	3.3
Gadwall				
104	M		2.0	2.6
89	F		1.8	3.0
Baldpate				
264	M		1.7	2.5
108	F		1.5	1.9
American Pintail				
937	M		2.2	3.4
498	F		1.8	2.4
Green-winged Teal				
199	M		0.8	1.0
81	F		0.7	0.9
Blue-winged Teal				
105	M		0.9	1.3
101	F		0.8	1.2
Cinnamon Teal				
26	M		0.9	1.2
19	F		0.8	1.1
Shoveller				
90	M		1.4	2.0
71	F		1.3	1.6
Wood Duck				
248	M		1.5	2.0
163	F		1.4	2.0
Redhead				
82	M		2.5	3.0
40	F		2.2	2.9

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 … 5)	Av. Lbs.	Max. Lbs.
Ring-necked Duck				
285	M		1.6	2.4
151	F		1.5	2.6
Canvas-back				
62	M		2.8	3.5
79	F		2.6	3.4
Greater Scaup Duck				
60	M		2.2	2.9
43	F		2.0	2.9
Lesser Scaup Duck				
130	M		1.9	2.5
144	F		1.7	2.1
American Golden-eye				
58	M		2.2	3.1
53	F		1.8	2.5
Barrow's Golden-eye				
3	M		2.4	2.9
7	F		1.6	1.9
Buffle-head				
23	M		1.0	1.3
26	F		0.7	1.3
Old-squaw				
31	M		1.8	2.3
14	F		1.4	1.8
Harlequin Duck				
5	M		1.5	1.6
4	F		1.2	1.3
Steller's Eider				
6	M		1.9	2.1
6	F		1.9	2.0
Northern Eider				
1	M		3.4	—
9	F		3.4	4.3

TABLE 1. (*Cont.*)

DUCKS (cont.)

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 5)	Av. Lbs.	Max. Lbs.
American Eider				
8	M		4.4	4.6
8	F		3.4	3.8
Pacific Eider				
8	M		5.7	6.2
4	F		5.4	6.4
King Eider				
14	M		4.0	4.4
9	F		3.6	4.1
Spectacled Eider				
8	M		3.6	3.8
4	F		3.6	3.9
White-winged Scoter				
13	M		3.4	4.0
19	F		2.7	3.4
Surf Scoter				
12	M		2.2	2.5
10	F		2.0	2.5
American Scoter				
8	M		2.4	2.8
4	F		1.8	2.4
Ruddy Duck				
12	M		1.3	1.8
17	F		1.1	1.4
Hooded Merganser				
24	M		1.5	2.0
20	F		1.2	1.5
American Merganser				
45	M		3.5	4.1
29	F		2.5	3.9
Red-breasted Merganser				
18	M		2.5	2.9
17	F		2.0	2.8

GROUSE

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 5)	Av. Lbs.	Max. Lbs.
Blue Grouse				
6	M		2.8	—
3	F		1.9	—
Spruce Grouse				
5	M		1.2	1.5
1	F		1.0	—
Ruffed Grouse				
159	M		1.3	1.7
164	F		1.1	1.5
Greater Prairie Chicken				
22	M		2.2	3.0
16	F		1.7	2.0
Attwater Prairie Chicken				
10	M		2.1	2.5
6	F		1.6	1.7
Lesser Prairie Chicken				
21	M		1.7	2.0
5	F		1.6	1.7
Sharp-tailed Grouse				
236	M		2.1	2.4
247	F		1.8	2.2
Sage Hen				
16	M		5.5	6.1
13	F		2.6	3.2

TABLE 1. (*Cont.*)

QUAIL, PHEASANT, AND WILD TURKEY

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Oz. (0 5 10 15)	Av. Oz.	Max. Oz.
European Partridge				
87	M		14.0	16.0
57	F		13.4	15.3
Bob-white				
899	M		6.1	8.8
692	F		6.0	9.0
Scaled Quail				
154	M		6.9	8.2
3	F		6.0	6.7
California Quail				
418	M		6.2	7.3
272	F		6.0	7.3

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Oz. (0 5 10)	Av. Oz.	Max. Oz.
Gambel's Quail				
145	M		6.0	7.3
103	F		5.7	6.8
Mountain Quail				
32	M		8.2	10.3
24	F		8.2	—
Mearns's Quail				
3	M		7.3	—
1	F		5.5	—

No. Birds	Sex	Av. Wt. Graph (0 5)	Av. Lbs.	Max. Lbs.
Ring-necked Pheasant				
6378	M		2.9	4.1
759	F		2.1	3.2

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Lb. (0 5 10 15)	Av. Lbs.	Max. Lbs.
Wild Turkey				
54	M		16.3	23.8
55	F		9.3	12.3

RALLIDAE

No. Birds	Sex	Av. Wt. Graph; 1/10 Inch = 1 Oz. (0 5 10 15)	Av. Oz.	Max. Oz.
King Rail				
3	M		11.2	12.0
Clapper Rail				
14	M		13.7	16.0
7	F		10.6	11.8
Purple Gallinule		38 Unsexed birds	7.6	9.3
Florida Gallinule				
1	M		16.0	—
3	F		10.5	12.0
American Coot				
17	M		20.2	26.0
12	F		17.4	21.0

No. Birds	Sex	Av. Wt. Graph (0 5)	Av. Oz.	Max. Oz.
Virginia Rail				
3	M		3.8	4.3
2	F		2.9	3.3
Sora				
4	M		2.1	3.0
4	F		2.1	2.8

TABLE 1. (*Cont.*)

WILSON'S SNIPE, WOODCOCK, AND DOVES

No. Birds	Sex	Av. Wt. Graph 1/10 Inch = 1 Oz. (0 5 10 15)	Av. Oz.	Max. Oz.
Wilson's Snipe				
15	M		4.5	5.5
14	F		4.1	5.5
Woodcock				
390	M		6.2	7.8
313	F		7.7	9.8
Band-tailed Pigeon				
2	M		13.1	14.0
1	F		12.8	—

No. Birds	Sex	Av. Wt. Graph (0 5)	Av. Oz.	Max. Oz.
Mourning Dove				
164	M		4.6	6.0
80	F		4.4	5.5
White-winged Dove				
9	M		5.5	6.4
2	F		5.4	5.8
Ground Dove				
3	M		1.5	—
1	F		1.5	

A METHOD OF MARKING RABBITS FOR FIELD STUDIES

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In studies of wild rabbits (*Oryctolagus cuniculus L.*) being undertaken by this Section it has been necessary to mark animals so that they can be identified individually from a distance without being caught. Niethammer (1937) marked wild rabbits (*O. cuniculus*) with white numbered tags in the ear, which he does not describe fully. He used them as an aid in distinguishing marked from unmarked animals and males from females, but not for individual identification. Hosley (1942), working on *Sylvilagus spp.*, used different coloured celluloid discs attached to aluminum tags inserted through holes punched in the ear for the same purpose as did Niethammer. Trippensee (1941) used markers of pyralin attached by staples to the ear and by combinations of nine colours could distinguish individuals 100 yards away. Southern (1940) also used celluloid discs attached to the ear of the wild rabbit (*O. cuniculus*) by a nickel pin like a paper clip. He used a yellow and a white series of discs, each with black two-figure numbers painted on them, and by means of a telescope he could identify individual rabbits 100 yards away. Although exact numbers are not given at least 140 rabbits were marked, and he claimed that losses of tags did

not exceed ten and that no loss was suffered after small backing discs were placed on the inside of the ear.

Initial Trial

For the present work Southern's method was adopted except that ordinary brass paper clips were used to attach the disc to the ear. The numbered disc, $\frac{3}{4}''$ in diameter * was placed outside the ear and the smaller backing disc, $\frac{1}{2}''$ in diameter, on the inside. After several months it became obvious that the tags were not staying on. For instance, in one of the experiments twenty rabbits were kept in an enclosure and weighed every month. Each month several of these had lost their tags and most of the remaining animals were suppurating around the tag hole. The loss of the tag was apparently due to sloughing of part of the ear tissue after necrosis. Irritation of the wound by the sharp edges of the paper clip and the prevention of circulation by pressure from the two discs were presumably the causes of necrosis. The paper clip was discarded as a means of attachment.

Description of New Method

An aluminum rivet was specially designed and it is the main subject of this note. This rivet did not cause irritation as it was inserted through a round hole punched in the ear. It was made with a shoulder on to which a washer was crimped, thus preventing any pressure on the ear from the two discs. The weight of the tag, which comprises two discs, a rivet and a washer, is 0.7 grammes and is light enough to be used on rabbits three weeks old.

The hole for the tag should be punched about $\frac{3}{8}''$ posterior to the median fold of the ear, but care should be taken to avoid puncturing a blood vessel. With such precautions there is little likelihood of the tag getting torn out, for when the rabbit lays its ears back the large outer tag is protected between the body and the ear, whilst the inner, smaller disc, is protected by the two folds of the ear.

An ordinary leather-worker's manual punch can be used to punch the hole if a piece of rubber is placed behind the ear to make a clean hole. This tool can also be adapted quite simply to crimp the rivet as well, by replacing one of the punches by the crimper.

The outer disc is $\frac{3}{4}''$ in diameter and can carry two figures $\frac{1}{2}''$ high. Numbers painted on with enamel paint tend to get scratched off, so that it is preferable to have the numbers engraved. One disadvantage of the rivet attachment is that the disc may rotate and consequently some numbers cannot be used, e.g., 66 or 99. If more than 100 animals are to be marked, different colours may be used for the discs, but the number of colours that can be distinguished from a distance is limited. The best colour combinations for this purpose seem to be white with black numbers, yellow with black numbers, and red with white numbers. If more animals were to be marked, letters could be combined with figures. For studies where sight observations are not being made, much larger numbers could be engraved with smaller figures.

Results

Three groups of rabbits were marked

* U. K. Plastics, Kingston-by-pass, Surbiton, England, supply these discs, already numbered, and in a variety of colours.

and the results are given separately as follows:—

(a) Fifty rabbits were kept for six months in a pen. They were marked when three to four weeks old. Of these one had the tag changed after a month because the inner disc was cutting into the median fold of the ear; and another tore the tag out after about two months. Except for these two cases, the tags have been entirely satisfactory on these rabbits, which have been under close observation.

(b) Wild Population No. 1. Over a period of five months 239 rabbits were marked in this population, and six months after the initial marking the population was poisoned and all the rabbits thus collected were inspected. One hundred and ten rabbits were recovered with tags, which had been on for the following lengths of time.—

TABLE 1.—NO. RABBITS MARKED AND RECOVERED FROM WILD POPULATION NO. 1

Tag retained (months)	1	2	3	4	5	Total
No. rabbits marked	74	48	60	23	34	239
No. rabbits recovered	38	21	33	10	8	110

One thousand two hundred and seventy-six rabbits without tags were also collected, of which three had holes in the ear that could have been made by a tag. As this sample represented a high proportion of the total population on the area it would appear that the lower proportion of marked rabbits from the earliest period was due to a higher animal disappearance rate rather than to a loss of tags. Had there been a heavy loss of tags, larger number of unmarked rabbits with tag holes would have been expected in the poison sample.

(c) Wild Population No. 2. This population has not been poisoned, so a true assessment of the loss of tags is not possible. However, Table 2 shows the number of rabbits marked in each month and the number seen by telescope or retrapped after seven months' marking operations.

TABLE 2.—NO. RABBITS MARKED AND RECOVERED FROM WILD POPULATION NO. 2

Tag retained (months).....	1	2	3	4	5	6	7	Total
No. rabbits marked	17	25	29	16	9	0	1	97
No. marked rabbits observed.....	12	16	22	15	7	0	1	73

During these operations three rabbits were caught with holes in their ears which could have been tag holes. Also, one rabbit was seen through the telescope to be losing its tag.

CONCLUSION

It is probable that in any method of marking that entails fastening a foreign body to the animal there will be individual animals that are more irritated than the rest, perhaps because of individual sensitivity or because of faulty application of the tag, and will tear the tag out. The small number of rabbits caught showing evidence of having lost tags indicates that the method described is a reasonably efficient one. Its success depends primarily on correct application of the discs and rivet, and care should be taken to see that all the parts of the tag are freely movable and will not hinder circulation or rub against the tissue of the ear.

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THE EFFECTS OF DDT UPON THE SURVIVAL AND GROWTH OF NESTLING SONGBIRDS

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INTRODUCTION

During the past seven years, numerous investigations have been made to determine the effects on songbirds of insect control with DDT. Diverse habitats as well as various methods of application, dosages, and formulations have been involved in these evaluations. The results are of considerable value in indicating conditions under which DDT may be detrimental to birds.

Previous studies have been based largely on effects of spray applications upon adult bird populations, an approach that is subject to admitted weaknesses (Stewart *et al.* 1946; Hotchkiss and Pough 1946; Benton 1951; Robbins *et al.* 1951). Nestling young have food demands in excess of adult birds and therefore may be considerably more vulnerable to poisoned food from DDT sprayings. In former investigations, (George and Mitchell 1947) some effort was made to obtain information on the effects of a DDT-contaminated environment on the development and survival of nestling birds. Resulting data, however, were not conclusive, partly because of difficulty in finding an adequate number of nests and also because of the normally high mortality rate of immature birds in nests. During the summers of 1949 and 1950 nest boxes were used to overcome these deficiencies. The methods employed in these studies and the results obtained are summarized here.

PROCEDURES

Nest boxes were erected in two experimental areas of about 20 acres each at the Patuxent Research Refuge, Laurel, Maryland. The two areas consisted of uncultivated fields about $\frac{1}{4}$-mile apart. Plant cover of the areas was largely herbaceous, but field and drainage-ditch

borders were grown up with a variety of trees and shrubs which supported a higher population and greater variety of breeding birds.

A total of 293 nest boxes was placed in the fields during February and March 1949. They were distributed at an average frequency of 3.5 boxes per acre in the open and about 45 feet apart along the edges and hedgerows. Each box was fitted with a manually-operated mechanism, which made trapping of adult birds for color banding possible (Fig. 1).

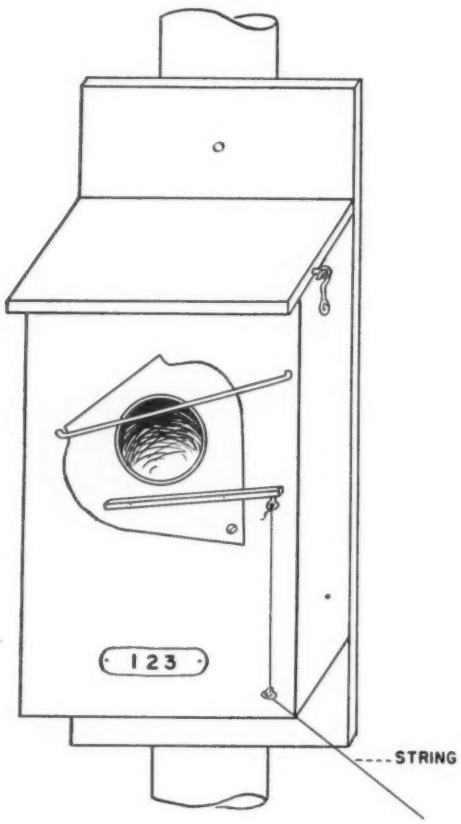

Fig. 1
Type of bird box used in experiment

The boxes were also equipped with an easily removable top to permit periodic checking of nest progress and weighing of nestlings.

Two aerial sprayings of DDT were made by the Division of Forest Insects, Bureau of Entomology and Plant Quarantine, on June 14, 1949 and June 6, 1950. The spray formula consisted of one pound of DDT per gallon of fuel oil, and application was made at the rate of 3 pounds of DDT per acre. Weather conditions were favorable, and the resulting spray deposits were quite uniform in both applications.

It was originally intended that one field be sprayed and the other maintained as a check. However, since the extent of nesting in the two areas differed markedly, each field was divided into a sprayed and unsprayed portion. As a result, there was an intermediate and indefinite border zone between each spray and control unit.

To determine breeding population changes resulting from the applications, censuses were taken on sprayed and check areas. During each of the two years, a total of 16 census trips, 8 before and 8 after spraying, were taken to ascertain the number of breeding territories as indicated by singing males. In addition, supplementary information was recorded on non-singing males, females, young, and the location of nests in and outside of boxes.

Adults using nest boxes were trapped and color banded. This made individual identification of these birds possible so that their movements and subsequent choice of nesting sites could be followed. It also aided censusing the adult populations.

Periodic inspections of nest boxes and regular visits to nests were made to ob-

tain information on hatching success and to determine the age of nestlings. By use of a triple-beam balance, daily weights were taken of young until they fledged. The young were retained in a small cardboard box while being weighed, and all weighings were taken in the field as close to the nest as possible. For the first five or six days after hatching, the total weight of all young in each nest was taken and an average was computed. After that, weights of individual birds were taken separately.

Because a reduced food supply in the sprayed area might retard growth of the nestlings, and might also lower their resistance to toxic effects of DDT, studies were made to determine the relative numbers of invertebrates in the two areas. Of the sampling methods used, sweepings gave the most reliable information on invertebrate populations. A sample consisted of fifty sweeps with a 15-inch insect net at each of two stations in the two areas. Inclement weather and other requirements of the study prevented taking samples at regular intervals. However, on the days that samples were taken in one area they were immediately followed by samples in the other, while weather conditions remained the same. All specimens in these samples were identified at least to order but only total numbers of invertebrates are reported here.

In 1949, a Calliphorid parasite, *Apaulina sialia* (S.&B.)*, was responsible for the mortality of a set of second-brood house wrens and two sets of bluebirds, one of the first brood and one of the second. Since these three nests were all in the unsprayed area, special attention was given to the extent of parasitism in 1950. As each nest was vacated, it was thoroughly searched for larvae and pupae of this species.

All dead birds recovered during the course of the experiment were analyzed for DDT. The Bureau of Entomology and Plant Quarantine analyzed those obtained in 1949, whereas 1950 mortalities were assayed by our own personnel. These analyses were conducted according to the Schechter-Haller colorimetric method. In 1949, the weight of the bird in the DDT-per-gram ratio includes weight of feathers, head, and feet, whereas in 1950, these parts were removed in preparing specimens for analysis. Consequently, figures for the two years are not entirely comparable.

EFFECTS ON ADULT SURVIVAL

A decrease in the adult population in the sprayed area and an increase in the unsprayed unit occurred both years following insecticide application (Table 1). Statistical analysis of these data does not show these population changes to be significant. The basic censusing information, however, may be misleading. Table 1 shows a population decrease of 6 percent after the 1949 spraying. A breakdown of this decrease by species reveals a loss of six of eight house wren territories and two of three bluebird territories. Severe losses in these two species are partly offset by slight gains in other species. These gains could have resulted from an influx of bachelor males into territories formerly held by males which either died or abandoned their territories in the sprayed area.

In 1950, two poisoned female Maryland yellowthroats and a nest of dead young which probably did not belong to

* Determined by Curtis W. Sabrosky, U. S. National Museum, Washington, D. C.

TABLE 1.—NUMBER OF BREEDING SONGBIRD TERRITORIES IN SPRAYED AND UNSPRAYED AREAS IN 1949 AND 1950
(Exclusive of starlings and swallows)

	Sprayed Area				Unsprayed Area			
	Pre-Spray	Post-Spray	Difference (No.)	Difference (%)	Pre-Spray	Post-Spray	Difference (No.)	Difference (%)
1949 (13 species).....	51	48	−3	−6	46	53	+7	+15
1950 (20 species).....	66	56	−10	−15	67	69	+2	+3

either of these females were found in the sprayed area two days after the application, but census data on Maryland yellowthroats for that year, show no reduction in the number of territories of this species following the spray. Either the males were not affected and they occupied the same territory regardless of the fate of their mates or brood, or other males took their places. Unless birds can be identified individually as by color bands or by the location of their nests, censusing by singing males may not provide a reliable population count in areas where mortality occurs.

EFFECTS ON ADULT BEHAVIOR

Post-spray abandonment of seven nests containing eggs was observed during the two years, four in the sprayed area and three in the check. Obviously these few abandoned nests do not provide any significant evidence that the spray caused adults to desert nests. Even with larger numbers, it would be impossible, in most cases, to separate mortality of adults from other causes for abandonment.

Color banding operations aided in following the movements and subsequent choice of nesting sites of some birds. In 1949, C. S. Robbins of the Patuxent Refuge staff followed parent birds on their foraging trips to ascertain any changes which might occur in territorial behavior. According to Robbins (unpublished manuscript), "In no case was any significant difference in feeding range observed following spraying."

During the course of experimentation, 31 re-nestings of house wrens and 18 of bluebirds were observed. Seven birds changed the location of their nests from the sprayed to the unsprayed area and seven others from the unsprayed to the sprayed. Twelve out of 19 (63%) re-established nests in the sprayed area and 23 out of 30 (77%) re-nested in the unsprayed area. There was no apparent avoidance of the sprayed area by parent birds selecting nesting sites.

EFFECTS ON NESTLING SURVIVAL

With 293 boxes available as nesting sites, 50 nesting attempts in 43 different boxes were made by four species in 1949, and 77 attempts in 60 boxes by five species in 1950. Not all data from occupied boxes were useful in considering the effects of spray application. House wrens were the most numerous and most productive and therefore provided the most reliable information on survival after spraying. Other hole-nesting species such as bluebirds, chickadees, and flickers did not occur in sufficient num-

bers to make valid comparisons of nesting success. Starlings were common enough, but the adults foraged primarily outside the area under observation and therefore were not considered appropriate subjects for this study.

On June 14, 1949, the date of spray application, six nests of first-brood house wrens had been established in bird boxes in the sprayed areas. Five of the six nests had young at the time of spraying, and 23 of 28 nestlings in them died. The sixth nest had eggs which did not hatch until 12 days after spraying. All four nestlings of this set survived. In the unsprayed area there were seven nests in which 36 of the 42 nestlings survived. Statistical treatment of these data (Table 2) shows a highly significant difference between the survival of the first-brood wrens in the two areas.

On July 8, twenty-four days after the spray was applied, the first hatching of second-brood house wrens was observed. A 60 percent hatch occurred in nests located in the sprayed area compared with a 96 percent hatch for those in the unsprayed tract. This 36 percent difference is probably the result of chance rather than of the spray, for the hatching success of the first brood in the unsprayed area in 1949 and 1950 exceeded that of the sprayed by only 5 and 11 percent respectively, while the hatching success of the second brood in the sprayed area in 1950 exceeded that of the check by 17 percent. Furthermore, the hatching success of the first-brood in the sprayed area in 1950 would have been 13 percent greater than that of the check had not ten eggs in the sprayed area been lost through predation. The low percent of fledging success for the birds in the check area in 1949 was attributed to an infestation of *Apaulina sialia* (S.&B.) which was responsible for the death of six young.

On June 6, 1950, when DDT was applied, there were 9 first-brood house wren nests located in the sprayed area and 11 in the unsprayed. In the sprayed area only one box contained young and these were 2 to 3 days old. The eggs of 2 nests hatched 4 days later and those in 3 others hatched on the 12th, 15th and 23rd of June respectively. The three remaining were destroyed by predation while still in the egg stage. The 8 nestlings present at the time of spraying and one nestling each in the broods that hatched on the 12th and 15th of June died. The remaining 23 nestlings survived until individuals in one box were sacrificed for chemical analysis of DDT content.

On July 1, twenty-four days after the

TABLE 2.—HATCHING AND FLEDGING SUCCESS OF HOUSE WRENS

	1st Brood						2nd Brood					
			Hatch		Fledged				Hatch		Fledged	
	No. Nests	No. Eggs	No.	%	No.	% (of hatch)	No. Nests	No. Eggs	No.	%	No.	% (of hatch)
1949												
Sprayed	6	38	32	84	9	28	3	15	9	60	9	100
Unsprayed	7	47	42	89	36	86	5	27	26	96	18	69
1950												
Sprayed	9	44	33	75	23	70	8	43	38	88	34	89
Unsprayed	11	65	56	86	41	73	7	38	27	71	24	89

spray application, the first second-brood wrens hatched. No significant difference appeared between the hatching and fledging success of the wrens in the eight nests in the sprayed area and the seven in the check.

In 1949, all first-brood bluebirds (12 in 3 nests) fledged before the spraying. At spraying time in 1950, however, there were 14 first-brood bluebirds in 3 nests in the treated area. Ten of these were 9 days old and 4 were 14. One nestling in a set of 5 that were 9 days old on June 6 was found dead in the nest on June 13, after the other 4 young had fledged.

Two active nests outside of boxes were under observation in the sprayed area at the time of DDT application in 1949. One contained 3 prairie warbler eggs and the other 4 six-day old wood thrush nestlings. The thrushes survived and fledged 6 days later. One of the prairie warbler eggs hatched 5 days later, and the young fledged after 9 days in the nest. On the second day following the application, a nest containing one dead and 3 live Maryland yellowthroat nestlings was found in the sprayed area. On the following day the remaining 3 were dead in the nest.

At the time the DDT was applied in 1950, eleven active nests of birds other than bluebirds, wrens, and starlings had been found in the sprayed area. The nest of an orchard oriole containing 5 eggs was unsuccessful as the eggs disappeared 9 days after spraying. A catbird nest having two eggs produced young 13 days after spraying, and both were fledged. The nest of a yellowthroat containing 3 eggs was abandoned as were a prairie warbler nest with 3 eggs and a field sparrow nest with 4 eggs. Four young Maryland yellowthroats, 1–2 days old at the time of spraying, were found dead 2 days later. The 5 remaining nests consisted of 2 chickadees (each with 5 young, 7–8 days old) and one each of yellow-breasted chat, towhee, and field sparrow (each with 4 eggs that hatched 7, 3, and 5 days later respectively). The young in all of these nests survived excepting those of the field sparrow, which were accidentally killed during mowing operations.

EFFECTS ON GROWTH

The effect on growth rate of house wrens depended in part on the time of hatching in relation to the spraying. In both years surviving young hatched before or shortly after spraying had growth rates well below the average for young house wrens in the check area. This was true of 5 broods in 1949 and one in 1950 that had hatched prior to the spraying, and of 4 broods in 1950 that hatched from 4 to 9 days after spraying. The one brood in 1949 which hatched 12 days after spraying, and the one in 1950 which hatched 17 days after application of DDT approximated young of the check area in rate of growth.

The weights of nestlings in 2 of the 3 nests of second brood wrens in the sprayed area in 1949 were only slightly below the average of wrens of the same age in the unsprayed area. Those in the 8 nests of the second brood in the sprayed area in 1950 fluctuated around the average weight of second-brood checks.

EFFECTS ON INVERTEBRATES

Sweeping samples were taken to meas-

ure the difference of invertebrate populations in the sprayed and unsprayed areas. The results showed that before spraying in 1949 the test area contained 1.8 times as many invertebrates as the check. One day, one week, two weeks and four weeks after the spray was applied, the unsprayed area contained, respectively, 17, 3.3, 2.4, and 1.8 times the number in the sprayed area. By the fifth or sixth week after spraying, invertebrate populations of the two areas closely approximated each other.

In 1950, sweeping samples revealed 1.5 times as many invertebrates in the check area as in the area sprayed the previous year. One day, one week, two weeks, and four weeks after the 1950 application, the unsprayed area contained, respectively, 6.3, 2.6, 1.8, and 1.8 times the number in the sprayed area. After an eight-week period the populations were comparable in the two areas.

The recovery rate of the invertebrate population as derived from these samples corresponds well with records on the lasting effects of the spray residues on the foliage. Experimentation on this subject was conducted by John Secrest of the Division of Forest Insects (unpublished manuscript). In these tests, foliage from the sprayed area was taken into the laboratory where reared nymphs of the American cockroach, *Periplaneta americana*, were exposed to it. This experiment showed that although sweetgum (*Liquidambar styraciflua*) foliage taken at some stations had sufficient poisonous residues to produce mortality for as long as eight to nine weeks after application, the residue on other foliage tested had lost most of its lethal qualities after a four-week period.

EFFECTS ON PARASITES

Observations on the blowfly, *Apaulina sialia* (S.&B.), in 1949 suggested that DDT might have protected nests from this parasite. In 1950 one first-brood nest in each area was found to be infested. Three larvae were recovered from the nest in the sprayed area and five pupae from the check nest. Six second-brood nests in the sprayed area and eight in the unsprayed contained 30 and 70 percent respectively of the 172 larvae and pupae taken from second-brood nests. Although as many as 63 parasites were found in one nest and 36 in another, there was no mortality from either of these infestations.

RECOVERY OF DDT IN TISSUES

Chemical analyses of dead birds collected during the course of experimentation are presented in Table 3. As expected, quantities of DDT recovered were in general greater in birds of the first brood than in those of the second. The greatest amount of DDT, 77 micrograms per gram of body weight, was found in a set of 8 first-brood house wrens that were 3 days old at the time of spraying in 1950 and died 5 days after the application. The next largest, 55.9 mcg./g., was detected in an adult female Maryland yellowthroat. This bird, found in the sprayed area two days after the 1950 application, exhibited signs of DDT poisoning.

A 38.3 mcg./g. quantity was found in a 5-day old house wren runt of the first brood that died 13 days after the spray was applied in 1950. Two of its nestmates, that were sacrificed for chemical tests 4 days later, had 6.2 mcg./g. of DDT. The remaining 3 individuals of the same nest, killed on the following

TABLE 3.—DDT CONTENT (MICROGRAMS PER GRAM) OF DEAD BIRDS COLLECTED DURING 1949 AND 1950

DDT (mcg./g.)	Area	Brood	Date Collected	Species	No. Indiv. in Sample
None.....	Check	1st	6/30/50	House Wren	1
Tr.	Check	1st	6/28/50	Phoebe	1
Tr.	Sprayed	2nd	8/8/50	House Wren	1
0.5.....	Check	2nd	6/20/49	Bluebird	4
1.1.....	Check	2nd	7/24/49	House Wren	6
2.6.....	Sprayed	1st	6/18/49	House Wren	6
3.1.....	Sprayed	1st	6/18/49	House Wren	7
3.3.....	Check	1st	6/20/49	House Wren	1
3.8.....	Sprayed	1st	6/20/49	House Wren	3
6.2*	Sprayed	1st	6/23/50	House Wren	2
6.4**.....	Sprayed	1st	6/24/50	House Wren	3
8.4.....	Sprayed	1st	6/16/49	Md. Yellowthroat	3
9.0.....	Sprayed	2nd	7/31/50	House Wren	1
11.0.....	Check	1st	6/20/49	House Wren	1
14.3.....	Sprayed	1st	6/26/50	House Wren	1
16.2.....	Check	1st	7/9/50	House Wren	1
18.7.....	Sprayed	2nd	7/14/50	House Wren	1
25.7.....	Sprayed	1st	6/8/50	Md. Yellowthroat	3
34.9.....	Sprayed	...	6/15/50	Field Sparrow (adult)	1
38.0.....	Sprayed	1st	6/13/50	Bluebird	1
38.3.....	Sprayed	1st	6/19/50	House Wren	1
55.9.....	Sprayed	...	6/8/50	Md. Yellowthroat (ad. F.)	1
77.0.....	Sprayed	1st	6/9/50	House Wren	8

* Killed before starvation.
** Killed after 24 hrs. starvation.

day, after being starved during the preceding 24 hours, contained 6.4 mcg./g.

Thirteen birds of the unsprayed area contained measurable quantities of DDT. The set of 4 second-brood bluebirds and the set of 6 second-brood house wrens in 1949, thought to have died from parasitism, contained small quantities of DDT. The 3 other individuals from the check area found to contain DDT in various amounts were each from a different nest. They were the only ones in their nest boxes that died before fledging and were the runts of their respective broods. One of these 3 nests was quite close to the sprayed area but the other 2 nests and the 2 parasitized nests were at a distance considered to be beyond the normal foraging range of the adults. However, all 4 of them were either close to or within a small area where, unfortunately, there were operations involving the use of DDT from which it is likely these individuals were poisoned.

It is interesting to note that in every case but one, when only a single nestling of a set died in the sprayed area it was a runt. The single exception was 11 days old when it died. It succumbed 20 days after the 1950 application and contained 14.3 mcg./g.

A second-brood house wren from the sprayed area in 1950, killed 54 days after the spray to determine DDT content, was found to have 9.0 mcg./g. of DDT. This individual presumably would have survived, since it was medium-sized and all its nestmates fledged.

The three sets of first-brood house wrens in 1949 in which there was no survival had only from 2.6 to 3.8 mcg./g. of DDT. These are seemingly low quanti-

ties. However, it must be kept in mind that the amount of DDT that constitutes a minimum lethal dose for juvenile birds is still unknown, and there has been no standard for correlating the quantity of DDT found in tissues and the quantity ingested. Furthermore, it is possible that the adults of birds of these nests were poisoned and the nestlings died as a result of abandonment rather than from receiving lethal dosages of DDT. This was not true, however, in the one instance in which a parent bird was observed feeding the remaining 2 of the 6 nestlings originally in the nest, one of which showed symptoms of DDT poisoning. Only 3.8 mcg./g. was detected in the individuals of this nest.

SUMMARY

In an experiment conducted during the summers of 1949 and 1950 at the Patuxent Research Refuge, Laurel, Maryland, two aerial applications of DDT were made at the rate of 3 pounds per acre. Sprayings were made over an experimental area of about 20 acres of abandoned fields bordered by woods and hedgerows. Two hundred and ninety-three bird boxes, with three different sizes of openings to accommodate various species of hole-nesting birds, were distributed throughout this area and in a similar check area of the same size. House wrens were the most numerous and most productive of the species restricting their activities to the areas under study, and therefore they provided the most reliable information on survival and growth-rate after spraying. A total of 149 nestling wrens were under observation in 1949 and 154 in 1950.

There were only slight decreases in the total adult bird populations, no increase in the number of cases of desertion, no significant differences in feeding ranges through the reduction of insect food, nor any apparent avoidance of the sprayed area by nesting birds.

DDT at the 3 pounds-per-acre dosage caused considerable mortality to young nestlings. The fledging success in six active first-brood wren nests in 1949 was 28 percent compared to 86 percent in the unsprayed check. In 1950, when the area was sprayed at an earlier date in respect to both the calendar and the nesting progress of the first-brood wrens, fledging success in the sprayed area was 70 percent compared to 73 percent in the check.

Average weights of first-brood wren nestlings in the sprayed area in both 1949 and 1950 were significantly lower than those in the check area. The weights of second-brood nestlings in 1949 were lower than those of the checks but the differences were not significant statistically. In 1950 the weights of second-brood house wrens in the sprayed area closely approximated those of the check.

Insect-sampling showed that shortly after spraying, the check area contained 17 times as many insects as the sprayed area in 1949 and 6 times as many in 1950. Six weeks elapsed in 1949 and 8 weeks in 1950 before the invertebrate populations in the two areas became similar. Since the density of insects necessary to sustain bird life in any area is unknown, it is uncertain to what extent this reduction in food contributed to the mortality of nestlings in the sprayed area or to their being underweight in comparison with the checks.

The blowfly parasite, *Apaulina sialia* (S.&B.), did not occur in sufficient num-

bers in 1950 to offer evidence as to whether DDT provided any protection to nestlings as was suggested by observations in 1949.

The chemical analyses of dead birds collected during the course of experimentation show a wide range in quantities of DDT present. For instance, quantities of DDT detected chemically in nestlings thought to have died from lethal dosages of DDT ranged from 2.6 to 77.0 micrograms per gram of body weight, and one set of wrens exhibiting symptoms of DDT poisoning contained 3.8 mcg./g. Runts from four different nests assumed to have died as a result of unsuccessful competition with their larger nestmates, however, were found to contain quantities of DDT ranging from 14.3 to 38.0 mcg./g. It is conceivable that nestlings inadequately fed or for other reasons being low in vitality could succumb to small quantities of DDT, whereas healthier individuals being nourished normally by their parents might survive for a longer period even though they consumed more DDT. Furthermore, it must be kept in mind that the amount of DDT that constitutes a minimum lethal dose for juvenile birds is still unknown. Also, there is no standard for correlating the quantity of DDT found in tissues and the quantity ingested.

RECOMMENDATIONS

Because of economic and aesthetic values, bird life should be considered in planning insect control programs. When control with DDT is necessary, treatment should be scheduled, if possible, to avoid the breeding season of most birds, which in areas with climatic conditions like that of Washington, D. C. extends from May through July. If the breeding season cannot be avoided entirely, damage to bird life can be minimized by making application a week or so before appreciable numbers of eggs hatch, or by delaying it until most nestlings have fledged. Data from 486 nests of 27 different songbird species obtained over a period of eight years at the Patuxent Research Refuge show that hatching of most eggs occurred between the middle of May and the third week of June, inclusive, and reached a peak during the first week of June. Therefore, in this area in most years there would be less damage to bird life if spraying were done before the second week in May or after the first of July.

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THE RELATION OF BALD EAGLES TO BREEDING DUCKS IN NEW BRUNSWICK

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This study was inaugurated in 1945 as a part of the study of the breeding ecology of the black duck in eastern Canada. It was materially assisted in the 1949–1950 seasons by a grant from the National Research Council of Canada which enabled a field assistant to be employed full-time on the project in those two summers. The observations were made by the author, the field assistant D. E. Banks, the waterfowl survey crew of the Northeastern Wildlife Station, and several observations were contributed by Howard L. Mendall, Leader of the Maine Cooperative Wildlife Research Unit.

The Nature of the Problem

The estuary of the St. John River in southern New Brunswick is probably one of the most important summer habitats of the bald eagle, *Haliaeetus leucocephalus leucocephalus*, Linn., in the northeast coastal region. At the same time it is the most important waterfowl breeding ground in the Maritime Provinces, and the local inhabitants are very keen duck hunters. The practice of shooting eagles to protect the ducks has been going on for many years, and the idea that the eagles are serious duck predators is well-entrenched.

The true role of the eagle as a predator on breeding ducks in this region was carefully studied through six field seasons.

The Method of Study

Regularly-used eagle feeding perches and sandbar feeding stations were located and an organized system of collecting prey remains was initiated. Observations of eagle meals were made from blinds, and food-preference tests were made with various combinations of bait. Relations with other wildlife of the region were noted at every opportunity, and 22 eagles were trapped and banded. Some of these birds were weighed and measured, and several were colour-marked with a broad band of bright yellow airplane dope around each wing.

Eagles were under observation for a total of 62 hours and 37 minutes during the intensive study in 1949–1950, and these observations were broken down as follows:—

Table 1.—Eagle Minutes of Observation

Activity	1949	1950	Total Eagle Minutes
Feeding.....	205	386	591
Fishing.....	201	204	405
Soaring.....	438	284	722
Perching.....	895	741	1,636
Unspecified...	348	35	383
Totals.....	2,087	1,650	3,737 (62 hrs., 37 min.)

The work was done in the estuary of the St. John river at the junction of the Grand Lake drainage and the main St. John. A 40-square mile area covering the shores of French, Indian, and

Maquapit lakes, the thoroughfares joining them, and Loder's and Portobello creeks in Sunbury County were intensively worked for prey remains. This area lies in 45° 50′ N and 66° 17′ W, and is shown in detail in the National Topographic Series Grand Lake Sheet. Data were gathered outside of the area incidentally to other station projects, but the systematic collection of prey remains was confined to it as it was found to be all one man could cover working alone. Aerial flights were made over the area by the Flyway Biologist of the U. S. Fish & Wildlife Service, and the author made two additional flights in 1950.

The habitat consists of timbered swamps, open marshes, sloughs, streams, and lakes. It is an important summer range for moose and deer. Black ducks, ring-necked ducks, American goldeneyes, wood ducks, blue-winged teal and green-winged teal nest on the area. There is a large colony of breeding great blue herons nearby. Crows and other common passerine birds of the region are present in numbers during the breeding season.

The streams and lakes support a resident population of eastern chain pickerel, brown bullhead, yellow perch, chub, and white sucker; in addition there is a heavy spring run of gaspereaux, or alewives, in all the creeks and streams. The common eel is numerous, and the sea lamprey runs up the main St. John and numbers float down dead in the late summer at the end of the breeding season. Thus there is an abundance and variety of fish for eagle food available during the duck breeding season.

The possible prey animals on the area are muskrats, minks, raccoons, skunks, snowshoe hares, and foxes. Turtles and snakes occur in limited numbers and in restricted habitats, and bullfrogs are common in the marshes.

The eagles therefore have their choice of mammals, birds, fish, amphibians and reptiles, and the first three are present in numbers.

THE EAGLE POPULATION OF THE ESTUARY

Eagles arrive in February, and may be seen around the first open water, but most of the summering population arrives in April after the spring break-up. The peak population is reached by August 1st. After this date there is a steady decline until only a few are left in mid-September. In 1949 the peak population on the 40-square mile study area was counted and estimated to be 54, and in 1950 it was 45. This is in excess of one eagle per square mile, which suggests a total population of at least 100 eagles in the area.

The U. S. Fish & Wildlife Service aerial waterfowl survey team saw more eagles in the St. John estuary than in the rest of the Maritime Provinces in total (Addy, verbal report), so that this region should provide a true picture of the role of the eagle in the ecology of breeding ducks in the northeast. They are not a local population, although there are a few breeding records. Banding recoveries show that birds raised in areas as far apart as Ontario and Florida summer in the estuary. Thus the eastern half of the continent may be considered as supplying eagles that use this habitat during the breeding season of the waterfowl.

The two main nesting areas in eastern North America are in Florida and in the Chesapeake Bay region of Maryland.

Broley (1950) reports serious losses of nesting sites in Florida which has sharply curtailed nesting in that important area.

THE FOOD HABITS STUDY

Actual observations of feeding eagles were combined with the analysis of prey remains gathered beneath feeding perches to form Table 2. This table shows the food eaten in 138 eagle meals consumed between March and November in the estuary.

These data show that 90 per cent of the food eaten in this sample consisted of fish of eight species, only one of which is fished commercially, the gaspereaux. Birds made up 9 per cent of the food eaten, and mammals 1 per cent. Black ducks were taken on six occasions during the breeding season, and one unidentified cripple was picked up behind a hunting blind in November. A crow caught in a muskrat trap was killed and eaten by three eagles, leaving only the legs in the trap.

The snowshoe hare was presumed to have been caught alive as there was no evidence to the contrary, but the beaver was carrion from a skinned carcass left behind by a trapper in early spring.

A single stomach from an adult male eagle shot by a fisherman on the Oromocto River in May contained 29.5 cc. of unidentified fish flesh.

The gaspereaux run is over by the second week of July, but during the run they are very numerous in every creek and stream. The numbers killed by the eagles is negligible, and many dead fish are picked up. The offal of the commercial fishermen provides many meals at this season as they dump their pickle vats on sandbars along the river. There is no evidence of eagle predation being of importance to the gaspereaux fishery.

TABLE 2.—EAGLE MEALS BY MONTHS—NEW BRUNSWICK (1945–1951 INCL.)
OBSERVATIONS PLUS PREY REMAINS

Food		Months										Total	
Class	Species	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	No.	%
Mammals	Snowshoe Hare	..	..	1	..	..	..	..	..	..	..	1	
	Beaver (carrion)	..	1	..	..	..	..	..	..	..	..	(2) 1	1
Birds	Black duck	..	..	1	..	1	1	3	..	..	..	6	
	Crippled duck	..	..	..	..	..	..	..	..	1	..	1	
	Unident. duck	..	..	..	1	..	1	..	..	..	..	2	
	Crow	..	..	..	..	..	1	..	..	..	..	1	
	Unident. bird	..	..	1	..	1	..	..	..	..	..	(12) 2	9
Fish	Perch	..	..	..	3	12	14	1	..	..	..	30	
	Brown Bullhead	..	..	..	2	14	5	2	..	..	..	23	
	Gaspereaux	..	..	..	12	6	..	..	..	..	..	18	
	Pickerel	..	..	1	2	5	4	4	..	..	..	16	
	Chub	..	..	..	5	3	4	..	..	..	..	12	
	White Sucker	..	..	..	1	5	6	..	..	..	..	12	
	Sturgeon (carrion)	..	..	..	..	..	..	1	..	..	..	1	
	Sea Lamprey (carrion)	..	..	..	..	..	1	..	..	..	..	1	
	Unident. fish	2	1	..	1	3	2	2	..	..	..	(124) 11	90
Totals:		2	2	3	28	50	39	13	..	1	..	138	100

RELATIONS WITH OTHER SPECIES

The ecological role of any predator cannot be accurately described by a foods habits study alone. The following are observations on the role of the eagles in the ecology of the region arranged by seasons to bring out more clearly the changing pattern that unfolds each year.

November-April

Eagle - Waterfowl:

Edwards (1950) reports heavy primary predation on ducks and Canada geese at the Sable River Sanctuary in Nova Scotia. He reports that the geese were eaten on the edge of the ice near where the kill was made, but that the ducks taken were carried off inland.

Shiras (1906) gives two instances of a bald eagle attacking duck decoys in the late fall, and Roosevelt (1899) describes a bald eagle overtaking and forcing a flock of five green-winged teal to dive into the water when in full flight to escape it. This was also in the duck shooting season.

Yeager (1950) reports an attempt by 12 bald eagles to capture a crippled gull on the Chautauqua National Wildlife Refuge near Havana, Illinois. They tried desperately to capture the gull which was in an open lake clear of any escape cover. They swooped on it many times, but it avoided each attack although it was unable to fly. This author concluded: "The inability of the eagles to capture the gull seemed to us to be good evidence that they could not be considered very important from the standpoint of primary predation. We were much impressed by the ability of the clumsy, crippled gull to elude their attacks." This also took place in midwinter.

Trautman (1942) reports an observation which shows the distrust of dabbling ducks for the bald eagle in winter. On February 6th of that year he observed an eagle flying over a mixed flock of about 500 blacks and mallards in a cornfield in Munroe County, Michigan. The ducks rose from the field and pursued the eagle in a long sinuous flock, the leader only 20–50 feet behind the eagle. It circled to gain altitude and then dived to outdistance its pursuers. The ducks then returned to the cornfield.

An eagle was reported preying on American golden-eyes at Land's End on the St. John River in March 1951 (Squires, 1951), and on April 13 an eagle was seen flying in a straight line over Musquash Island lagoon in the estuary. It flew on a steady course and at the same altitude, about 100 feet, toward large rafts of blacks, Canada geese, and green-winged teal, causing the waterfowl to rise ahead of it. It paid no attention to them and continued on its way, but the behavior of the waterfowl showed clearly that the eagle was recognized as a potential predator.

The foregoing are evidence that during the late fall, winter and early spring the bald eagle may become a primary predator on waterfowl in the northeast. The efficiency of the individual eagle no doubt improves with practice, so the crippled gull which so successfully eluded the Illinois eagles might not have had such success with the Nova Scotia eagles which were accustomed to catching blacks and Canada geese. It seems fair to say therefore that the bald eagle may become an important factor in the survival of wintering waterfowl in local areas in this region, but the number of eagles wintering in the north is but a

small fraction of the number present in summer so that the total loss to eagle predation is not large.

Eagle - Crow:

An adult eagle was seen chasing crows around a hole in the ice of the St. John River at Fredericton on March 14, 1949. It rose from the ice and circled until over the crows which were standing along the edge of the open water, then swooped on them. It did not succeed in making a capture while it was under observation as the crows were very alert and avoided its dives by scattering in all directions.

May-October

Eagle - Waterfowl:

The eagle meals shown in Table 2 were mainly taken in this period and show the heavy preponderence of fish in the diet during this season. Young black ducks made up 4.5 per cent of the meals observed, and these ducks appeared to be taken by individual eagles which had continued preying on the ducks into the summer season as their remains were found under the same perches. In the great majority of cases the eagles paid no attention to the breeding ducks during the summer, and the following are sample observations.

On June 20, 1950, a mature eagle was watched for some time sitting in a tree with a female wood duck and seven ducklings feeding under it. Each was apparently aware of the presence of the other but the duck showed no fear and the eagle appeared quite indifferent to their presence.

On August 9 of the same year a female black duck and eight downy young were observed swimming directly under an immature eagle perched in a tree about 15 feet above them. Again neither paid any attention to the other.

An eagle was observed to fly about 20 feet directly above a brood of goldeneyes on the study area. It paused and looked down at them and then continued on its way. The female gave the alarm call when the eagle paused and the ducklings put their necks out flat on the water and started to scatter, but when the eagle showed no interest in them they returned to the female.

It was considered possible that the relative availability of fish and waterfowl as food might be the deciding factor in the eagles' choice, and in order to test this food preference tests were carried out by offering an assortment of food with the same availability. These tests offered five species of fish, one mammal, and one bird, and the baits were placed below an occupied feeding perch.

Various combinations of bait were offered during 21 set-nights between June 18 and September 7. The sets were visited and some of the bait taken each night up to August 24, but between then and September 7, 4 set-nights were unvisited as most of the eagles had left the estuary.

TABLE 3.—FOOD PREFERENCE OF BALD EAGLES IN SUMMER

Bait	Times Offered	Times Accepted	% Accepted
Black Duck	11	0	0
Snowshoe Hare	4	0	0
Brown bullhead	5	5	100
White sucker	7	5	71
Eastern Chain Pickerel	11	7	64
Chub	10	3	33
Perch	7	0	0

The black duck and the snowshoe hare were always offered in combination

with fish of one or more species. In no case did the eagle take either although they were within a few feet of the fish. This would indicate that with equal availability the eagles prefer fish as food at this season. The tests were run under several feeding perches in different parts of the study area to eliminate the possibility that it was the same eagle or group of eagles that were taking the bait each night. Brown bullheads were the preferred species as they were taken every time they were offered, and they were chosen from a number of combinations of fish baits.

Eagle - Osprey:

A pair of ospreys nested in a tall elm on the Oromocto Flats in 1950. The male was seen to dive on and attack an immature bald eagle that flew across the territory. The eagle turned over in mid-air to meet the attack. They seemed barely to touch and the eagle rolled over to continue on its course while the osprey returned to its perch above the nest. Only once was an eagle seen to rob an osprey.

Eagle - Great Blue Heron:

Eagles were seen perched in trees within a few feet of great blue herons on several occasions. The herons appeared to have no fear of the eagles and used their feeding perches regularly as resting places. A large colony of breeding herons is within three miles of the study area. Numbers of young herons are seen on the area in late summer. There is no evidence of eagle predation on this species.

Eagle - Crow:

Crows were seen to follow an eagle to scavange the remains of its meals, and occasionally to mob it as they do an owl. This did not appear to disturb the eagle as it continued to drowse on a perch in the sun despite the screaming, diving crows. However a crow needs only to be incapacitated to provide a meal for an eagle.

BANDING AND COLOUR MARKING

Eagles were trapped at a fish bait wired to an anchor in shallow water and surrounded at a distance of 14 inches by four or five No. 1½ single-spring traps. The bait was wired down to prevent the eagle picking it up from the air. Padding was found to be unnecessary in traps of this size. The sets were made on a known sandbar feeding station, or in shallow water near an occupied feeding perch. They were reasonably selective as the only other victim taken was a crow which was scavanging eagle leavings along the shore.

Twenty-two eagles were trapped and banded, and 12 immature birds and two adults were marked with a broad band of bright yellow airplane dope around each wing. Marked birds were seen on the study area three times later in the season, and one bird was seen a month after marking. This suggests that handling during measuring, banding, and colour-marking did not disturb them sufficiently to cause them to leave the area as soon as they were released. Two recoveries were made from Delta, Ontario and St. Petersburg, Florida, and one of the birds banded on the area was shot that fall in Washington County, Maine.

Twenty immature eagles had an average wing-spread of 6 feet, 8 inches, a maximum of 7 feet, 6 inches, and a minimum of 5 feet, 6 inches. Six immature birds averaged 15 lbs. 6 oz. in

weight, with a maximum of 16 lbs. 8 oz. and a minimum of 14 lbs. The only adult that was weighed and measured had a wing-spread of 7 feet and weighed 14 lbs.

CONCLUSIONS

The evidence presented indicates that the bald eagle in New Brunswick in summer is a scavenger and fisheater which rarely turns to birds for food, and still less frequently to mammals. Freshwater coarse fish of about nine species are its principal diet. Only one of these species is of commercial importance, and eagle predation is a negligible factor in reducing its numbers.

The eagles summering in the region come from the eastern half of the continent, and most of them have returned south by early September. As the freeze-up comes those eagles remaining in the north are deprived of their main food supply in the freshwater streams and lakes and must turn to the coastal waters. Here they find the procuring of fish food to be considerably more difficult, and they are forced to turn more and more to birds and mammals. As the winter progresses and shore ice forms in the shallows, they have been known to concentrate around flocks of wintering waterfowl and to become predators of first importance. However the total number of eagles remaining in the north throughout the winter is not large, and their depredations are of only local importance.

At the first signs of open water inland they leave the coast once more for the freshwater habitat and resume their fish diet as soon as possible. The waterfowl gradually lose the fear of the eagles they have acquired during the winter months and both pass the summer together in harmony on the marshes. A few eagles persist in taking ducks at intervals all summer, but they are the exceptions. Instances of eagles in close proximity to broods of young ducks have been frequently observed when the eagle pays no attention to the ducks and they show no fear of the eagle.

The popular belief that the eagles are serious predators of young ducks and should be shot as a conservation measure throughout the summer is not supported by these findings. Their effect upon the production of waterfowl in this region is negligible, and the beneficial effect of their scavenging the offal of commercial fishermen decidedly outweighs the slight damage they do to the breeding ducks.

A MANAGEMENT RECOMMENDATION

The data presented strongly indicates the eagle's preference for fish food even when birds and mammals are equally available. In such areas as the Sable River Sanctuary in Nova Scotia where a few eagles pass the late winter months living on waterfowl, this predation could be lessened or even eliminated if some source of fish food such as cannery offal or a net-load of alewives were made available to them at some distance from the sanctuary. If such a source were placed on an off-shore reef or island the evidence indicates that the eagles would turn to it in preference to preying on the waterfowl.

This type of artificial feeding would only be necessary for two or three months, and a supply of sufficient size to last through the critical period could be laid out in one operation.

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A TROUT POPULATION STUDY ON A SMALL CREEK IN GALLATIN COUNTY, MONTANA [1]

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INTRODUCTION

An investigation of the population and ecology of trout in Trout Creek, Gallatin Valley, Montana was made during the summers of 1950 and 1951 and the intervening winter. This stream is one of numerous small spring-fed creeks which occur in the area.

Somewhat similar studies on trout stream populations have been made by Stefanich (1952) on Prickley Pear Creek, Montana; Schuck (1945) on Crystal Creek, New York; Needham, Moffett, and Slater (1945) on Convict Creek, California and Shetter and Leonard (1943) on Hunt Creek, Michigan.

The writer wishes to acknowledge the assistance of Dr. C. J. D. Brown who directed the study and helped prepare the manuscript. Invaluable aid in setting up electric shocking equipment was given by Dr. A. R. Jordan and Mr. H. G. Helterline; identifications of aquatic plants were verified by Dr. W. E. Booth; free access to the portion of the creek studied as well as other cooperation was given by Messrs. Hugh Spain, Radford McGuire, Wilbur Spring and Ralph Herdina. Several students at Montana State College also assisted, especially Marvin Boussu and William Clothier who helped collect field data and Jack Bailey who assisted in aging the fish. The Montana Fish and Game Department allowed use of certain equipment, assisted in preparation of the scale mounts, and provided use of the state shocking crew on one occasion. The Montana State College Agricultural Experiment Station gave financial assistance.

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DESCRIPTION OF CREEK

Trout Creek is 3½ miles northeast of Belgrade, Montana at an altitude of approximately 4,450 feet. It originates in springs which are scattered along its entire length and meanders through a fertile agricultural area for a distance of 4 miles to where it enters the East Gallatin River. The drainage is about seven square miles.

Study Area and Sections

Observations were confined to the upper 2½ miles of the creek. Four representative 300-foot sections were established without bias as to pools, riffles and cover. Starting with the uppermost, these study sections were designated 1, 2, 3 and 4 (Fig. 1).

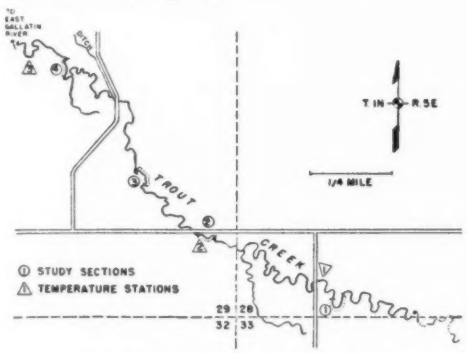

FIG. 1. Trout Creek study area.

Pertinent physical measurements were made in each section (Table 1). Widths and depths were determined when water levels were intermediate between March low water and September high water levels. Average widths were based on measurements made every 5 feet along the creek and in general increased progressively going downstream. Riffles within sections had an average midstream depth of 6.3 inches, and pools, a maximum depth of 31 inches. The bottom in riffle areas was usually composed of small gravel. In calm areas sand and silt prevailed.

Velocity and volume of flow measurements were made in fall when high water levels were being approached. Velocities were measured with a current meter half way between the surface and bottom at 12–15 equal intervals across the creek. Both velocity and volume of flow increased from the upper to the lower part of the study area. During the investigation two flash floods were caused by melting snow. One on February 9 and 10, 1951 and the other on March 26. The volume during these floods was estimated roughly to be seven times greater than in the fall. Floods of this nature were reported to be an an-

TABLE 1.—COMPARISON OF PHYSICAL CHARACTERISTICS OF STUDY SECTIONS

	Section			
	1	2	3	4
Length (feet)	300	300	306	300
Average width (feet)	5.5	10.4	15.5	15.5
Area (acres)	0.038	0.072	0.109	0.107
Riffles—per cent of section length	22	50	33	40
Pools[1]—per cent of section length	13	44	49	39
Volume of flow (cu. ft. per sec.)	2.36	9.07	12.21	14.72
Average velocity (ft. per. sec.)	0.75	1.75	1.82	2.00
Average depth (inches) of stream at place where velocity was measured	8.2	7.7	5.9	5.5

[1] At least 12 inches deep.

nual occurrence. They caused washing of the stream banks and scouring of the bottom. The flow in section 4 was reduced approximately 20 per cent for 2–3 weeks during the summer due to an irrigation diversion.

In the upper two-fifths of the study area, (section 1 included) Trout Creek flowed through a small ravine in which willows (*Salix* sp.) were frequent. Section 1 had little shade from willows but was narrow enough so that overhanging sedges (*Carex rostrata* and *C. nebraskensis*) and other herbs covered a considerable portion of the creek surface (Fig. 2). The lower three-fifths of the study area (sections 2, 3 and 4 included) was more open. Much of it was bordered by low banks with occasional clumps of willows and other shrubs (Figs. 3 and 4). Sections 2 and 3 had several well shaded pools. Section 4 was completely open. There was less undercut bank in section 3 than in the others.

FIG. 2. Upper part of study area (section 1).

Aquatic plants were present in the study area from early summer until mid-winter. They were most dense in section 1 and least dense in section 4. In section 1 (Fig. 2) water cress (*Nasturtium officinale*) predominated. It choked the edges along most of the section and occurred as mid-stream patches which in places extended from bank to bank. There were also occasional patches of a narrow-leafed pondweed (*Potamogeton* sp.) with foliage three to six inches long, and a small amount of brook grass (*Catabrosa aquatica*). In the lower three sections water cress was common along the edges while separate patches of water speedwell (*Veronica connata*), brook grass and pondweed were found in midstream. In section 2 brook grass and water speedwell predominated and in sections 3 and 4 water speedwell was most abundant (Fig. 3). Filamentous algae were prevalent in the creek in summer and fall.

Temperatures

Year around water temperatures were secured at the upper, middle and lower portion of the study area (Fig. 1). These were taken with Taylor "Sixes" maximum-minimum thermometers and were usually recorded three or four times a month from August 1950 to October 1951.

Temperatures at the three stations followed a similar pattern of fluctuation. At station 3 (Fig. 1), where spring water

had the least moderating effect, maximum temperatures were 3–6 Fahrenheit degrees higher than those at the other stations from mid-July through September and minimum temperatures usually 1–3 degrees lower from mid-November to mid-March. Here the average maximum in summer (June through August) was 60 degrees F. (highest: 63) and the average minimum,

Fig. 3. Middle part of study area (section 3).

Fig. 4. Lower part of study area (section 4).

45 degrees F. The average maximum in winter (December through March) was 49 degrees F. and the average minimum, 37 degrees F. (lowest: 32). At station 1 maximum summer temperatures were at times 2–4 degrees higher than those at station 2 due to warmer water from a small tributary entering the uppermost part of the study area.

Chemical Analyses

Limited chemical analyses using standard limnological methods were made at various points along the study area on March 1 and July 27, 1951. Chemical conditions in and below section 1 were found to be comparable on both dates and conditions at all points were well within the range tolerated by trout with the possible exception of low dissolved oxygen (24 per cent saturated) and high free CO_2 (30.0 p.p.m.) at the source on March 1. Dissolved oxygen and pH increased going downstream while free CO_2 decreased. In the study sections pH ranged from 7.5 to 8.1 and free CO_2, from 3.0 to 13.0 p.p.m. On both dates water in section 1 was 77 per cent saturated with oxygen and in section 4 approximately 100 per cent.

In general the dissolved salt content decreased going downstream. On March 1 total hardness in the lower and upper study sections varied from 222 to 232 p.p.m. (as $CaCO_3$), and total alkalinity (methyl orange) from 204 to 223 p.p.m. Conductivity ranged from 450 to 500 $\times$ 10^{-6} mho per centimeter at 25 degrees C.

Species of Fish Present

Trout were by far the most numerous fish. Rainbow trout (*Salmo gairdnerii*) and eastern brook trout (*Salvelinus fontinalis*) predominated. Brown trout (*Salmo trutta*) were less numerous. Hybrid rainbow x cutthroat trout were probably present, but no attempt was made to separate them from the rainbow trout. Freshwater sculpins (*Cottus* sp.) were present in considerable numbers. Other fish collected included six young mountain whitefish (*Prosopium williamsoni*), three large suckers (*Catostomus* sp.) and one longnose dace (*Rhinichthys cataractae*).

METHODS

Population Inventories

Fish were collected by the direct electrical current method (Rayner, 1949). Power was supplied by a small 250-watt D. C. generator which was protected by a fuse but operated without a rheostat or meters. Two triangular-shaped electrodes formed by wrapping 16 gage copper wire horizontally on a wooden frame were employed (Shetter, 1948). A small pair each with 14-inch base, 15-inch height and $\frac{1}{4}$-inch interval between wire windings was used in section 1, and a large pair each with 24-inch base, 18-inch height and $\frac{3}{8}$-inch windings was used downstream. The electrodes were mounted on wooden handles and were connected to the generator by 100 feet of rubber-insulated cable. The shocker could be operated with a minimum of two men.

A unit of stream up to 150 feet long was blocked at each end with $\frac{1}{2}$-inch square mesh seines. The energized electrodes were worked up- and downstream within the area until no fish with a total length greater than 3–3$\frac{1}{2}$ inches was taken. Fish were retrieved with a dip net of $\frac{1}{4}$-inch square mesh and held in

live boxes covered with ordinary window screen.

A 0.5 per cent urethane solution was employed to anesthetize captured fish (Gerking, 1949). Total lengths were taken to the nearest 0.1 inch and weights, to the nearest 0.01 pound. Fish were marked by cutting off one or more fins flush with the body surface. A different fin was clipped for each section (section 1, right pectoral; 2, left pectoral; 3, right pelvic and 4, left pelvic) and a distinctive combination of two clipped fins was used for each location outside the study sections. The amount of error caused by regenerated fins was not determined. It was considered unimportant, however, since the lapse from the first to the final inventory was only one year and fins that had started to regenerate were again clipped from recaptured fish in each collection. Fish smaller than $3\frac{1}{2}$ inches in length were so numerous in some collections that the majority were counted but not measured. After fish were processed they were held in a live box until fully recovered and then released into the portion of the creek from which they were captured.

Known casualties were light. Of 2,440 fish handled from May through September 1951 (recaptures considered as new fish) only 20 (0.8 per cent) were immediate casualties. All were less than 4 inches long and 5 were less than 2 inches long. Of the 20, 9 were believed to have died from handling rather than from the effects of electricity. An additional 2–3 per cent of the fish were caught by their gills in the wire of the positive electrode. Fish 4–5 inches in length were mostly affected. Undoubtedly some of these fish were injured, though no mortality was observed. Approximately 2 per cent of the fish had body burns caused by contact with an electrode.

The equipment was very satisfactory for making population inventories on Trout Creek where undercut banks and areas of dense aquatic vegetation prevailed. The fish were attracted to the positive electrode where they were easily captured. Few were stunned.

About 10 feet was the maximum distance the electrodes could be apart and have the shocker effective. In one field test a voltmeter was used and the generator output was found to be 138 volts with the large electrodes completely submerged at this interval. The interval between the electrodes was normally 6–8 feet. Each bank had to be worked separately with both electrodes to draw fish from the undercut. Efficiency was low in pools more than 3–4 feet deep.

Several efficiency tests patterned after those of Haskell and Zilliox (1941) were made during the summer of 1951. Blocking nets were installed and an initial run made through the enclosed area with the shocker. Fish taken were marked with a distinctive notch on the anal or dorsal fin and returned within a minute or two to the place where captured. The estimated lengths of the fish were recorded. This procedure was followed until from 10 to 30 fish of all sizes were marked and then, starting over again, the population was completely inventoried using the method described previously. The percentage of recaptured marked fish was used as an indication of efficiency.

Two tests were made using the large electrodes. The first upstream from section 1 in a 49-foot length of stream averaging $3\frac{3}{4}$ feet wide. There was a

total of 16 fish involved in the final collection. All of the marked fish (5) from 4.2 to 6.9 inches long were recovered and 4 of 5 marked fish less than 3½ inches in length were recovered. The second test was in a 120-foot portion of section 3. Here, nearly three hundred fish were involved in the final collection. Of 14 marked fish from 4.4 to 9.4 inches long, 13 were recaptured; and of 15 fish less than 3½ inches, 10 were recovered.

A third test was made using the small electrodes in a 150-foot portion of section 1. In this experiment an hour interval was allowed between marking the fish and starting the final shocking. There were 84 fish in the final collection. All of the marked fish (13) from 5.0 to 8.1 inches long were recovered and of 9 marked fish less than 3½ inches in length, 8 were recovered.

Combining the results of these tests, in the 3½ inch and larger size group 31 of 32 marked fish were recovered giving an efficiency of 97 per cent. In the smaller size group 22 of 29 marked fish were recovered giving an efficiency of 76 per cent. Although these tests were not as extensive as would be desirable and have other shortcomings as pointed out by Schuck (1948), they did indicate the efficiency of population inventory methods used in this study. The percentages derived were the basis for correcting population figures used in determining age composition, survival of wild trout and standing populations.

Aging

Approximately 1,600 scale samples were taken as a basis for determining the age composition of trout populations. Of this number 836 were studied. Of these, 685 were from fish collected in the regular inventories and 151 were from other collections. A subsample of 10 individuals was used for each ½-inch size group in which there were sufficient scale samples. All available scale samples were studied for size groups in which the class frequency was below this level (Ketchen, 1950). This was done for each species in each season, the two summers being treated separately.

Subsampling was used mainly to verify the assumption that fish in a well represented model-size group in the length-frequency distribution were all of the same age. Fish in poorly represented size groups, where overlap was possible, were aged by reading scales from the exact fish concerned. However, scale samples were available for only about 50 per cent of these specimens. In several instances recaptured fish that could be definitely identified were aged by using scales taken in earlier collections. About 15 whose ages were questionable were assigned to age groups on the basis of size.

Annuli were determined with the aid of a scale projection machine. Studies showed that the annulus formed in the spring and all fish were credited with having a new annulus after January 1 even though it was not completed (Hile, 1948). There was reasonably close agreement between the ages determined by the scale method and those shown by length-frequency distributions. A detailed study of annulus formation will appear in a later paper.

Weight Assignment (Unweighed Fish)

Average weights for each trout species were determined for 0.1 inch length intervals, the average for any one length

being based on all fish of that size weighed. These averages were used to assign weights to individual rainbow and brown trout not weighted in the first shocking of sections 2 and 4 and to a few fish from other inventories which escaped before being weighed.

The length-weight relationships for small brook, rainbow and brown trout cited by Carlander (1950) were used as the basis for the weights of fish less than 3 inches in length since weights were not taken on fish of this size. Weights for each 0.1 inch length-interval were obtained from curves constructed on the basis of these data. Weights of larger fish taken from the curves agreed reasonably well with actual weights obtained in the field.

Where fingerlings less than $3\frac{1}{2}$ inches long were counted rather than weighed and measured, weights were assigned in proportion to the calculated weight of fingerlings actually measured in the same collection or in collections made a short time previously.

Hatchery Fish

A total of 1,016 (4-inch) brook trout from the U. S. Fish and Wildlife Service Hatchery at Bozeman, Montana was planted in the two middle study sections on August 14, 1950. One-half was distributed uniformly through each. An effort was made to minimize the effect of handling. The fish were marked by removal of the adipose fin, treated with a brine solution and then held at the hatchery for 10 days prior to being planted. There were no fatalities during this period. Marked fish were transported to the creek in aerated water which was never more than 10 Fahrenheit degrees above that at the hatchery (49° F.). Before removal of the fish from the hatchery truck, the water in the tank was tempered to within 4 Fahrenheit degrees of the temperature of the creek water (51° F.).

On September 14, one month after planting, sections 2 and 3 were inventoried by shocking. Thirty-eight hatchery fish were found in seetion 2 and 24 in section 3. In the November inventory, 8 were found in section 2 and 23 in section 3. In the spring shocking period (May-June 1951), none was found in section 2 and only 2 in section 3. During the final shocking period (August 1951) no hatchery fish were found in either section.

In 1951 (February-September) approximately one-fifth of the study area was shocked not including portions repeated. During this period 10 hatchery fish were found and none of these was over 6.8 inches. If there were no recaptures (fish captured more than once) and the area covered was representative of the entire study area, there would be an estimated 50 hatchery fish, or 5 per cent of the original plant, present in the entire study area during the calendar year following planting. This result is nearly equivalent to an estimated survival of 6.3 per cent (from one September to the next) reported by Schuck (1948) as the highest for several plantings of brown trout fingerlings in Crystal Creek, New York. His figure was based on inventories made by the electric shock method.

A total of 135 hatchery fish including recaptures was caught during the entire investigation on Trout Creek. Hatchery fish were found throughout the entire study area. There was no discernible

pattern of movement away from the original planting sites.

WILD TROUT POPULATIONS

Except for the marked hatchery fish planted during the study, the fish in Trout Creek were considered to be wild fish. There were no records of recent plantings by the local hatchery and the majority of fish captured were less than three years old.

Dates of Inventories

The fish populations in the four study sections were inventoried at five main shocking periods as follows: July 25–August 24, 1950; September 14, 1950 (sections 2 and 3 only); October 28–November 19, 1950; May 17–June 3, 1951 and August 4–12, 1951. Other portions of the study area were shocked at irregular intervals throughout the period of investigation.

Species Distribution

The different species of trout showed a definite pattern of distribution in the study area. Brook trout predominated at the upper end. In section 1 their numbers comprised 83–96 per cent of all trout in the regular inventories (Table 2). Rainbow trout predominated in the lower three sections where they constituted 70–92 per cent (Tables 3, 4, and 5). The first inventories of sections 2 and 4 show a lower percentage of rainbow trout because insufficient effort was made to capture young of the year. The progressive change from predominately brook trout in the upper part of the study area to predominately rainbow trout in the lower part is demonstrated by comparing the yearling classes in each section during the main inventories (Tables 2, 3, 4 and 5). As a general rule the number of brook trout yearlings progressively decreased going downstream while the number of rainbow trout yearlings increased. For example in the August 1951 inventory the number of brook trout yearlings was 36, 20, 9 and 1 in sections 1 to 4 respectively while in the same sections the number of rainbow trout yearlings was 4, 37, 45 and 56.

Brown trout were found throughout the lower three-fifths of the study area but were nowhere the predominant species. Only two were found, one on each of two occasions, in the upper two-fifths of the study area. They were never found in section 1.

There were noticeably fewer sculpins in section 1 than in the others. This area was judged to be inferior habitat for the species.

Population Changes Between Inventories

The numbers and weights comprising the age groups of each trout species at each shocking are presented to show population changes between shocking periods (Tables 2, 3, 4 and 5). These data indicate a numerical increase in young of the year, especially rainbow trout, from spring (time of hatch) through late fall. This is probably not the case since there should be a maximum at hatching followed by a progressive decrease through the year. The apparent increase is most likely due to collecting methods and also to insufficient efforts being made in the early collections to capture young of the year.

To determine the pattern of numerical changes for rainbow trout older than young of the year, all inventories were

TABLE 2.—SECTION 1. TROUT NUMBERS AND WEIGHTS (POUNDS) IN EACH INVENTORY

Species and age group	Date of shocking: Aug. 24, 1950 No.	Aug. 24, 1950 Wt.	Nov. 18, 1950 No.	Nov. 18, 1950 Wt.	May 20, 1951 No.	May 20, 1951 Wt.	Aug. 12, 1951 No.	Aug. 12, 1951 Wt.
Brook (hatchery)			2	0.06	1	0.02	1	0.05
Brook (wild)								
0	51	0.63	53(22)[1]	1.33	3	0	101	0.77
I	45	3.57	77(25)	9.67	48(14)	1.70	36(18)	2.83
II	1	0.19	2	0.74	20(13)	2.50	0	0
III & older	0	0	0	0	0	0	0	0
Total	97	4.39	134(47)	11.80	72(27)	4.22	138(18)	3.65
Rainbow								
0	1	0	13 (1)	0.18	0	0	0	0
I	10	0.45	13 (4)	0.58	9 (1)	0.22	4 (1)	0.18
II	1	0.24	1 (1)	0.25	1 (1)	0.07	1	0.12
III & older	0	0	0	0	0	0	0	0
Total	12	0.69	27 (6)	1.01	10 (2)	0.29	5 (1)	0.30
Grand total	109	5.08	161(53)	12.81	82(29)	4.51	143(19)	3.95
Lbs./acre		134		337		119		104

[1] Figures in parentheses = numbers of recovered fish marked previously in this section. Fish from other sections are treated as unmarked.

TABLE 3.—SECTION 2. TROUT NUMBERS AND WEIGHTS (POUNDS) IN EACH INVENTORY

Species and age group	Date of shocking: July 25, 1950[1] No.	July 25, 1950[1] Wt.	Sept. 14, 1950 No.	Sept. 14, 1950 Wt.	Nov. 19, 1950 No.	Nov. 19, 1950 Wt.	May 30, 1951[2] No.	May 30, 1951[2] Wt.	Aug. 4, 1951 No.	Aug. 4, 1951 Wt.
Brook (hatchery)			38	1.07	8	0.23	0	0	0	0
Brook (wild)										
0	7	0.07	25 (5)[3]	0.37	12 (2)	0.23	0	0	72 (2)	0.60
I	22	2.17	27(10)	3.32	12 (5)	1.91	12 (4)	0.51	20 (4)	1.90
II	1	0.19	1	0.32	0	0	7 (3)	0.86	4 (4)	0.92
III & over	0	0	0	0	0	0	0	0	0	0
Total	30	2.43	91(15)	5.08	32 (7)	2.37	19 (7)	1.37	96(10)	3.42
Rainbow										
0	7	0.03	209 (6)	1.13	314(82)	2.39	1	0	204	0.52
I	24	1.22	23(10)	1.51	12 (7)	0.88	58(14)	1.36	37(20)	2.15
II	2	0.63	3 (2)	0.84	0	0	13 (8)	1.92	8 (4)	2.51
III & over	1	0.41	1 (1)	0.73	0	0	1	0.94	0	0
Total	34	2.29	236(19)	4.21	326(89)	3.27	73(22)	4.22	249(24)	5.18
Brown										
0	0	0	1	0.02	0	0	0	0	3	0.02
I	3	0.25	4 (2)	0.46	4 (2)	0.71	0	0	0	0
II	0	0	0	0	1	0.58	5 (4)	1.30	4 (3)	1.47
III & over	0	0	0	0	1	1.69	1	2.99	1	3.90
Total	3	0.25	5 (2)	0.48	6 (2)	2.98	6 (4)	4.29	8 (3)	5.39
Grand total	67	4.97	332(36)	9.77	364(98)	8.62	98(33)	9.88	353(37)	13.99
Lbs./acre		69		136		120		137		194

[1] This section was 482 feet long on this date. Before the next shocking it was reduced to 300 feet. Numbers and weights have been corrected in proportion to the reduction in section length.

[2] Four young of the year not classified to species are omitted. These were marked and returned to water.

[3] Figures in parentheses = numbers of recovered fish marked previously in this section. Fish from other sections are treated as unmarked.

TABLE 4.—SECTION 3. TROUT NUMBERS AND WEIGHTS (POUNDS) IN EACH INVENTORY

Species and age group	Date of shocking: Aug. 9, 1950		Sept. 14, 1950		Nov. 4, 1950		June 3, 1951[1]		Aug. 11, 1951	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Brook (hatchery)			24	0.72	23	0.95	2	0.13	0	0
Brook (wild)										
0	12	0.13	11 (2)[2]	0.21	9 (2)	0.18	0	0	53 (4)	0.57
I	17	2.01	9 (6)	1.08	15 (6)	2.22	10	0.57	9 (2)	0.83
II	0	0	0	0	0	0	1	0.18	2 (1)	0.69
III & older	0	0	0	0	0	0	1	0.43	0	0
Total	29	2.14	44 (8)	2.01	47 (8)	3.35	14	1.31	64 (7)	2.09
Rainbow										
0	129	0.47	158(17)	1.02	258(51)	2.05	0	0	332 (1)	1.04
I	49	2.92	26(17)	2.01	17(12)	1.51	114(13)	3.36	45(33)	2.91
II	3	0.90	5 (3)	1.86	2 (2)	0.78	18 (5)	2.72	6 (3)	1.59
III & older	1	0.51	0	0	2	1.26	1	0.60	0	0
Total	182	4.80	189(37)	4.89	279(65)	5.60	133(18)	6.68	383(37)	5.54
Brown										
0	2	0.01	2	0.03	3 (2)	0.05	0	0	12 (1)	0.11
I	3	0.52	2 (2)	0.42	4 (2)	1.24	1	0.06	1 (1)	0.14
II	0	0	0	0	1	0.56	0	0	0	0
III & older	0	0	0	0	4	8.43	0	0	0	0
Total	5	0.53	4 (2)	0.45	12 (4)	10.28	1	0.06	13 (2)	0.25
Grand total	216	7.47	237(47)	7.35	338(77)	19.23	148(18)	8.05	460(46)	7.88
Lbs./acre		69		67		176		74		72

[1] Twelve young of the year not classified to species are omitted. These were marked and returned to water.

[2] Figures in parentheses = numbers of recovered fish marked previously in this section. Fish from other sections are treated as unmarked.

treated as if they were from the same year thus giving a sequence from spring through summer and fall. On this basis rainbow trout older than age group 0 showed maximum numbers in the first inventory of the year and then a more or less progressive decline to the last inventory of the year. This is best shown by section 3 where there were 133 in June 1951, 51 in August 1951 (53 in August 1950), 31 in September 1950 and 21 in November 1950. Rainbow trout of this age category in sections 2 and 4 showed a similar decrease in numbers. This pattern was expected since at the first of each year the yearling class is recruited from the numerically strong young of the previous year. Section 1 was an exception to the above pattern presumably because brook trout was the predominant species. No information was secured during the rainbow trout spawning season to show whether or not they increased at that time.

Although in the regular pattern the number of fish in each class decreased through the year, the loss in total weight due to reduction in numbers was offset to a large extent by the gain in weight of individual fish. This was well demonstrated by the August 1951 shocking of section 2 (Table 3). Here half the age groups older than young of the year showed a decrease in number but an increase in weight when compared to those in the May 1951 shocking.

TABLE 5.—SECTION 4. TROUT NUMBERS AND WEIGHTS (POUNDS) IN EACH INVENTORY

Species and age group	Date of shocking: Aug. 1, 1950[1] No.	Aug. 1, 1950[1] Wt.	Oct. 28, 1950 No.	Oct. 28, 1950 Wt.	May 17, 1951 No.	May 17, 1951 Wt.	Aug. 5, 1951 No.	Aug. 5, 1951 Wt.
Brook (hatchery)			7	0.30	0	0	0	0
Brook (wild)								
0	12	0.19	2 (1)[2]	0.04	0	0	4	0.07
I	14	1.79	6 (3)	0.98	0	0	1	0.12
II	0	0	0	0	3 (1)	1.08	0	0
III & older	0	0	0	0	0	0	0	0
Total	26	1.98	15 (4)	1.32	3 (1)	1.08	5	0.19
Rainbow								
0	34	0.11	376 (3)	3.16	0	0	154	0.55
I	52	3.46	22(15)	2.56	95(13)	2.19	56(21)	4.84
II	1	0.11	2	0.41	3 (1)	0.72	2 (1)	0.55
III & older	0	0	0	0	0	0	0	0
Total	87	3.68	400(18)	6.13	98(14)	2.91	212(22)	5.94
Brown								
0	12	0.09	13 (2)	0.32	0	0	20	0.24
I	3	0.45	7 (3)	1.84	1	0.02	0	0
II	0	0	0	0	2 (1)	0.99	1	0.44
III & older	0	0	3	7.11	2 (1)	2.86	0	0
Total	15	0.54	23 (5)	9.27	5 (2)	3.87	21	0.68
Grand total	128	6.20	438(27)	16.72	106(17)	7.86	238(22)	6.81
Lbs./acre		58		156		73		64

[1] This section was 504 feet long on this date. Before the next shocking it was reduced to 300 feet. Numbers and weights have been corrected in proportion to the reduction in section length.

[2] Figures in parentheses = numbers of recovered fish marked previously in this section. Fish from other sections are treated as unmarked.

While the same pattern of numerical decrease through the year probably existed for the overall population of brook and brown trout, it was not confirmed by data on Trout Creek. The October-November inventory was taken during the spawning season of these species and showed a decided numerical increase of yearlings and older fish. Only section 1 showed a pronounced increase in the number of brook trout. Here the yearling group increased from 45 in August 1950 to 77 in November. The numbers of spawning brook trout did not markedly increase in the other sections which had predominantly rainbow trout.

The increase in brown trout older than the 0 age group in the October-November inventory is best demonstrated by sections 3 and 4. Section 3 showed an increase from 2 in the September 1950 shocking to 9 in November and section 4 showed an increase from 3 in August 1950 to 10 in late October. Both sections showed a reduction of brown trout older than young of the year in later inventories.

In the October-November inventory sections 1, 3 and 4 each had a total trout weight double that for the same section in any other inventory. For example, in section 1 the total weight in this inventory was 12.81 pounds. The next highest was the August 1950 inventory with a total weight of 5.08 pounds (Table 2). These increases were

due largely to the influx of brook or brown trout and to a lesser extent the increased weight of young of the year.

Needham, Moffett and Slater (1945) studied fluctuations of a brown trout population over several years and found there was usually a gain in total pounds per mile over the summer period because of the growth of individual young of the year.

Section 2 did not show an increase in total trout weight from the September to the October-November inventory. The presence of two large brown trout accounted for the increase in weight of this species. There was a reduction in both brook and rainbow trout weights.

The two summer inventories (July-August 1950 and August 1951) were compared. Section 1 showed a 22 per cent reduction in total trout weight from 1950 to 1951 due mainly to a decrease of 28 per cent in the number of yearlings and older fish. This was the only section that showed a decrease in weight. Section 2 showed a numerical increase in most age groups; the total weight more than doubled. Part of this increase may be attributed to an improvement in collecting methods after the July 1950 shocking of this section. In sections 3 and 4 the total trout weight did not change markedly from summer to summer. Comparison of numbers of each trout species from summer to summer (young of the year excluded) showed a 28 per cent decrease in brook trout and an 11 per cent increase in rainbow trout for the combined four sections.

Movement and Population Stability

About 3,200 wild trout were marked during the investigation and most of these (nearly 2,400) before the May-June 1951 inventory. Altogether about one-quarter of the study area was covered by shocking operations. A total of 57 fish (28 brook, 27 rainbow and 2 brown trout), including repeats, were recaptured more than 500 feet from the stream section in which they were originally taken. Of these, 26 had traveled between $\frac{1}{2}$ and 1 mile, and 5 over a mile. The greatest distance covered was that of a rainbow trout which traveled about $1\frac{3}{4}$ miles in a downstream direction. The observations indicated about equal up- and downstream movement, however, the sampling technique was not designed to quantitively measure the direction of movement.

Limited movement was indicated by observations of fish captured immediately above or below the section in which they had been marked. In one collection 12 fish marked in section 1 were found outside the section but within 220 feet of its upper boundary. On practically every occasion when collections were made adjacent to a study section, marked fish from the nearby study section were found.

The extent to which trout remained in one area was indicated by a comparison of the number marked in any one section to the number recaptured in the same section. This was tabulated for each section in each inventory (Table 6). Although the number available theoretically increased as additional fish were marked in each inventory, the number of recaptures did not increase proportionally. For example, in the September 14, 1950 inventory of section 3 there were 47 recaptures of 183 trout marked on August 9. The number of recaptures in this section fluctuated in the Novem-

ber and June inventories, but in the August 1951 inventory there were still only 46 recaptures of 686 fish marked. Sections 2 and 4 showed similar patterns.

Table 6.—Wild Trout Marked and Recovered in Each Section

Section and date shocked	Number marked	Number previously marked	Number recaptured	
Section 1				
Aug. 24, 1950	107	...	..	
Nov. 18, 1950	101	107	53	(32.4)[1] [2]
May 20, 1951	47	208	29	(36.7)
Aug. 12, 1951	11	255	19	(46.3)
Section 2				
July 25, 1950	106[3]	...	..	
Sept. 14, 1950	256	106	36	(42.4)
Nov. 19, 1950	249	362	98	(46.7)
May 30, 1951	64	611	33	(34.0)
Aug. 4, 1951	155	675	37	(47.3)
Section 3				
Aug. 9, 1950	183	...	..	
Sept. 14, 1950	144	183	47	(66.7)
Nov. 4, 1950	225	327	77	(48.9)
June 3, 1951	134	552	18	(12.3)
Aug. 11, 1951	160	686	46	(63.5)
Section 4				
Aug. 1, 1950	191[3]	...	..	
Oct. 28, 1950	280[4]	191	27	(52.5)
May 17, 1951	86	471	17	(16.0)
Aug. 5, 1951	131	557	22	(36.7)

[1] Numbers in parentheses are the percentages of the population made up by recaptured fish, excluding young of the year.
[2] Low due to influx of spawning brook trout.
[3] Sections 2 and 4 were 482 and 504 feet long respectively in the first inventory when these fish were marked. Each was reduced to 300 feet before the next shocking.
[4] An estimate. About 125 young of the year not marked; this possibly reduced the percentage of the population made up by recaptures in later shockings.

An indication of population stability was also obtained by comparing the percentage of the population (excluding young of the year) which was recaptured fish from inventory to inventory. This was done for each section (Table 6). The percentage was especially constant from inventory to inventory for section 2. As a whole these figures seem to indicate that the percentages of the population made up by recaptures would be fairly consistent were the inventories at equal intervals. The spring inventory (May-June), for all sections except section 1, showed a reduction in the actual number of recaptures as well as a reduction in the percentage of the population (yearlings and older) made up by recaptures. This was expected because of the 6–7 month interval which had elapsed since the October-November inventory. The effect of the two flash floods that occurred during this period is not known. Section 1 showed a progressive decrease in the number of recaptures from the November 1950 to the August 1951 inventory. There was also a progressive reduction of trout numbers in this section.

The greatest percentage recovery of marked fish occurred in section 1 where 107 trout were marked on August 24, 1950; 53 (50 per cent) were recovered 86 days later on November 18.

Discussion of Population Stability

There apparently was a population turnover greater than that which could be expected from normal mortality and recruitment. As pointed out, additional fish were marked at each inventory yet marked fish did not accumulate from inventory to inventory. Also, at least 45 per cent of the yearlings and older fish were "new" fish in all inventories where marked fish were available. Shetter and Hazzard (1939) found populations of rainbow, brook and brown trout to be relatively unstable in short sections (about 100 feet) of certain Michigan streams. They computed the net percentage loss of marked trout to be 44–

94 per cent from month to month. This was based on the number of marked fish returned to the water after any one inventory compared to the number recaptured in the next. For the Trout Creek study sections the net percentage loss of marked trout (computed by the same method) was 81–94 per cent during the 6–7 month interval from October-November 1950 to May-June 1951 and 61–79 per cent during the 2–3 month interval from May-June to August 1951.

The changes in population from inventory to inventory could only have been caused by movement or some mortality factory such as predation, angling, etc. While there was evidence of movement over short distances, the study did not demonstrate emigration from this small creek to the river below. Shocking and handling may have influenced movement.

Mortality from shocking is not considered to be an important factor. Smith and Elson (1950) tested the lethal effects of collecting trout and salmon with a D. C. shocking apparatus. They concluded that delayed mortality was not significant and that fish recovering immediately could be assumed to be uninjured. The writer does not believe urethane was deleterious. Gerking (1949) described it as nontoxic when used in proper concentrations. Fin clipping, however, may be a cause of mortality, especially when the pectoral fins are removed (Wales, 1947; Shetter, 1951). Pectoral fins were clipped from fish in the upper two study sections of Trout Creek. The effect on the population was not determined.

The paucity of rainbow and brook trout older than age-group II indicated a rapid population turnover. Inasmuch as older fish were scarce at the time of the first as well as later inventories this condition could not be attributed to shocking or marking. The observations made do not disclose the cause of this unexpected loss of older fish. Fishing pressure was considered to be of minor importance since there were few fishermen on the study area after the first 3–4 weeks of the fishing season. Kingfishers, great blue herons and mink were present and four fish with wounds presumed to be beak marks were found. Predation by these animals was not believed to have had a serious effect on the population.

Standing Populations

The standing population of trout in the study area was computed on the basis of the August 1951 inventory (Table 7). The numbers and weights were corrected for the efficiency of the shocking method as explained under age composition. Corrected figures showed 1,495 trout to be in the four study sections. These had a total weight of 34.7 pounds. This is equivalent to 4,586 trout or 106 pounds per acre. Rainbow trout

TABLE 7.—CORRECTED NUMBERS AND WEIGHTS OF TROUT IN AUGUST 1951 INVENTORY. DATA FROM ALL SECTIONS COMBINED

	Brook trout		Rainbow trout		Brown trout	
Age group	No.	Wt. (lbs.)	No.	Wt. (lbs.)	No.	Wt. (lbs.)
0.....	297	2.60	908	2.78	44	0.47
I.....	69[1]	5.90	146	10.37	1	0.14
II.....	6	1.61	18	5.06	5	1.91
III & older	0	0	0	0	1	3.90
Totals.....	372	10.11	1,072	18.21	51	6.42

[1] One hatchery trout (0.05 pounds) included.

comprised 72 per cent by number and 52 per cent by weight; brook trout, 25 per cent by number and 29 per cent by weight; and brown trout 3 per cent by number and 19 per cent by weight.

As already pointed out, in the October-November inventory the total weights in sections 1, 3 and 4 were at least double those in other inventories. At this time section 1 was computed to have a standing crop of over 300 pounds per acre—by far the largest standing crop for any section. The upper two study sections each carried more pounds per acre during 1951 than either of the lower two sections (Tables 2, 3, 4 and 5).

In the corrected August 1951 inventory fish of legal size (7 inches and over) made up approximately 2, 3 and 14 per cent by number and 35, 27 and 93 per cent by weight of the rainbow, brook and brown trout respectively. Legal rainbow trout in this inventory averaged 8.3 inches and 0.25 pounds; brook trout, 8.3 inches and 0.22 pounds; and brown trout, 11.2 inches and 0.85 pounds. There were 197 legal trout per mile of the study area based on corrected figures.

The eight largest fish captured during the study period were brown trout ranging from 18.4 to 25.5 inches. The largest rainbow trout was 17.9 inches and the largest brook trout 12.3 inches.

The standing crop of 106 pounds per acre for the study area as a whole in August 1951 is comparable to the standing crop of 94.40 pounds of brook trout per acre (plus 9.68 pounds of muddlers) found by Shetter and Leonard (1943) in a section of Hunt Creek, Michigan. In their study legal size fish (7 inches and over) comprised 2.3 per cent by number and 19.4 per cent by weight of the brook trout population as compared to 3 per cent by number and 27 per cent by weight in the present study on Trout Creek.

Age Composition

The August 1951 inventory of all four sections was used as the basis for determining the age composition of the wild trout population in the study area. The total number in each age group from all four sections was compiled for each species of trout. These numbers were corrected on the basis of efficiency tests described above in which 76 per cent of the fish less than $3\frac{1}{2}$ inches in length and 97 per cent of those $3\frac{1}{2}$ inches and over were recovered (Table 7). Weights were corrected by determining the average weight in each age group and multiplying it by the corrected number of fish.

The age compositions of the rainbow and brook trout populations were comparable. In each the young of the year group predominated numerically. It comprised 85 per cent of the rainbow and 80 per cent of the brook trout. This age group was a considerably less important component of population weights making up only 15 and 26 per cent. Yearlings (one annulus) comprised 57 and 58 per cent respectively of the rainbow and brook trout weights but only 13 and 18 per cent of the numbers. Two-year-olds (two annuli) made up 28 and 16 per cent of rainbow and brook trout weights and 2 per cent of the numbers of each species. There were no older rainbow or brook trout taken in this inventory.

The age structure of the brown trout population differed markedly from that of the rainbow and brook trout in August 1951 since the yearling group was

of minor importance (one fish) while fish two years old or older comprised 90 per cent of the weight. The age structure of this species had changed considerably since the previous summer. In the July-August 1950 inventory there were nine yearling brown trout and none older.

Survival

Estimated rates of survival for wild eastern brook and rainbow trout were computed from corrected inventory figures for the various age groups (Tables 7 and 8). Survival was computed by two methods: (1) by comparing numbers in age groups of one inventory with those in an earlier inventory; (2) by comparing age groups in a single inventory with each other. The young of the year sample in the July-August 1950 inventory was not considered representative for either species and was not used to estimate survival of this age group.

TABLE 8.—CORRECTED NUMBERS OF WILD BROOK AND RAINBOW TROUT IN INVENTORIES USED FOR RATE OF SURVIVAL COMPUTATIONS[1]

Inventory	Brook trout				Rainbow trout			
	Age group				Age group			
	0	I	II	III & older	0	I	II	III & older
July-Aug. 1950...	..[2]	101	2	0	..[2]	139	7	2
Oct.-Nov. 1950...	81	113[3]	2	0	1,243	66	5	2
May-June 1951...	..[2]	72	32	1	..[2]	285	36	2

[1] Figures shown are totals for all study sections.
[2] Sample inadequate.
[3] High due to influx of spawning fish.

The estimated survival of young of the year rainbow trout over the 12-month period (August to August) was 16 per cent when based on the ratio of age group I to age group 0 in the August 1951 inventory. This was comparable to the estimate of 12 per cent survival for nine months (November to August) based on the ratio of age group I in the August 1951 inventory to age group 0 in the October-November 1950 inventory. Estimated survival from age group I to age group II from August to August was about 12.5 per cent by either method.

The survival of young-of-the-year brook trout for nine months (November to August) was estimated to be 84 per cent based on the ratio of age group I in the August 1951 inventory to age group 0 in the October-November inventory. The survival for 12 months if based on the age composition of the August 1951 inventory would be only 23 per cent. This method of computation is not considered valid in this instance. It depends on uniform recruitment from year to year and this apparently was not the case. There were 81 young of the year in the October-November 1950 inventory and 297 in the August 1951 inventory. The writer does not believe the three months difference in season of capture accounts for this variation in numbers. Survival of yearling brook trout over a 12 month period was estimated to be 6 per cent on the ratio of age group II in the August 1951 inventory to age group I in the July-August 1950 inventory. There were no brook or rainbow trout in age group III in the August 1951 inventory; therefore, there was no apparent survival for age group II and older from August 1950 to August 1951.

Shetter and Leonard (1943) estimated the year to year survival of a brook trout population in a section of Hunt Creek, Michigan to be 65.9 per cent from age group 0 to I. This is somewhat comparable to the estimate of 84 per cent for nine months in the Trout Creek study.

Their estimates of 64.3 per cent survival from age group I to II and 13.7 per cent from age group II to III are much higher than estimates for brook trout studied from Trout Creek. Schuck (1948) analyzed Shetter and Hazzard's (1939) data of a summer's seinings of three Michigan streams and estimated the survival from fingerlings to yearlings to be 14 per cent for rainbow trout (very similar to estimate for Trout Creek) and 52 per cent for brook trout (lower than estimate for Trout Creek).

Growth

All growth estimates were based on the August 1951 inventory. This was chosen because: (1) the time lapse from beginning to end was comparatively short (8 days); and (2) most collections by other workers have been made during summer, so that a collection in this season made the data more comparable. Growth of rainbow and brook trout was estimated from the average total lengths of each age group at time of capture. All measured fish from all sections were included (Table 9).

Table 9.—Total Lengths of Brook and Rainbow Trout in Each Age Group (August 1951 Inventory)

Species and age group	Number of fish	Total lengths at capture (inches)	
		Average	Range
Brook			
0.....	230	2.90	2.0– 4.1
I.....	66	6.08	4.7– 9.1[1]
II.....	6	8.80	8.0– 9.7
Rainbow			
0.....	326	2.12	1.0– 3.3
I.....	142	5.50	3.7– 8.3[2]
II.....	17	8.63	6.5–12.6

[1] Standard deviation: 0.8.

[2] Standard deviation: 0.9.

Young-of-the-year rainbow trout had an average length of 2.1 inches compared with 2.9 inches for brook trout. The difference was probably due to the earlier hatching date of brook trout. Some individuals of each species attained legal length (7 inches) in their second summer, however, the majority did not reach this size until their second fall or the following spring. This growth rate is somewhat better than that reported by Purkett (1951) for the rainbow and brook trout in the Bridger Creek system which is also tributary to the East Gallatin River. Here both rainbow and brook trout averaged 6.6 inches at time of second annulus formation. Phenicie (1950) found that in 12 of the 17 Montana streams sampled rainbow trout did not reach legal length, on the average, until the third year of life.

Comparisons of samples from the various sections of Trout Creek indicated a small but progressive increase in rate of growth from the upper to the lower end of the study area. However, the samples were not large enough to serve as conclusive evidence.

Natural Reproduction

Judging from the large number of fingerling trout, conditions must have been very favorable for natural reproduction in Trout Creek. Corrected inventory figures indicate there were 1,340 young of the year in the four study sections (1,206 feet) in October-November 1950 and 1,249 in August 1951. The species composition differed in the two years. In the October-November inventory about 93 per cent were rainbow trout, 6 per cent brook trout and 1 per cent brown trout. In the August 1951 inventory about 73 per cent were rain-

bow trout, 24 per cent brook trout and 3 per cent brown trout. Based on these corrected inventory figures there were 5,867 young of the year per mile in late fall (October-November) 1950 and 5,468 per mile in August 1951. Needham, Moffett and Slater (1945) in a study of the wild brown trout population in Convict Creek, California found that natural reproduction contributed an average of over 2,750 fish per mile each year. This was in a portion of stream with an average width not much different from that of the Trout Creek study sections. Their maximum figure was 4,905 per mile which is nearly equivalent to the number found in Trout Creek.

Brook trout collected on November 18, 1950 in section 1 were used for determining age and sex ratio. This collection was selected since brook trout predominated and were spawning at that time. Some males in their first year of life were ripe. Eight of 55 young of the year (including two hatchery fish) taken in this collection exuded milt when light pressure was applied to the belly. These ranged from 4.1 to 4.8 inches in length. The youngest females found to be ripe were yearlings. The smallest of these was 6.3 inches.

Sex was determined only for brook trout which were ripe. This included majority of those over six inches in length. These were predominately males. A total of 67 included 48 (72 per cent) males, 14 (21 per cent) females and 5 (7 per cent) whose sex was not determined. The unbalanced sex ratio could be caused by males maturing and moving into spawning areas at a younger age than females. However, this apparently is not the case since recaptured fish, i.e., those marked previously in this section, showed the same predominance of males. Of 17 recaptured fish longer than 6 inches, 12 (70 per cent) were males, 2 (12 per cent) were females and 3 (18 per cent) could not be designated as to sex.

Ripe brown trout in the October-November inventory indicated that their spawning season coincided at least in part with that of the brook trout. The youngest brown trout found to be ripe were yearlings. The sample of this species was too small to give reliable information on sex ratio.

SUMMARY

1. A study of a rainbow, brook and brown trout population in Trout Creek, a small spring-fed creek in the Gallatin Valley, Montana, was made during two summers and the intervening winter. The populations in two study sections were inventoried four times and in two other study sections five times during the investigation. Fish taken were finclipped and released. A direct current shocker was used for sampling the population.

2. A total of 1,016 marked 4-inch brook trout were planted in August 1950. An estimated 5 per cent remained in the 2½ mile study area during the following calendar year.

3. The different species of trout showed a definite pattern of distribution in the study area. Brook trout comprised 83–96 per cent of the trout numbers in the uppermost study section where the stream was narrow. Rainbow trout comprised 70–92 per cent in the lower three study sections.

4. Rainbow trout older than age group 0 were at their maximum number in the first inventory of the calendar

year (May-June) due to recruitment of young fish and then gradually declined in number to the last inventory of the year (October-November). The loss in total trout weight due to the reduction in number through the year was largely offset by the gain in weight of individual fish. Brook trout (upper study section) and brown trout older than young of the year increased markedly during their spawning seasons.

5. A population turnover greater than expected from normal mortality and recruitment was indicated by low recoveries of marked fish theoretically available and by the paucity of brook and rainbow trout over two years old. There was evidence of limited movement.

6. The estimated standing crop per acre in August 1951 in the four study sections combined was 4,586 trout or 106 pounds (197 legal sized trout per mile). Of the brook and rainbow trout numbers, 80 and 85 per cent respectively were in age group 0; 18 and 13 per cent were in age group I and 2 per cent of each were in age group II. There were no older specimens of either species.

7. The estimated survival (August to August) of rainbow trout between age groups 0 and I was 16 per cent or less; between age groups I and II, about 12.5 per cent. The estimated survival of brook trout between age groups 0 and I from fall to summer (nine months) was 84 per cent; between age groups I and II from August to August, 6 per cent.

8. The average total lengths (inches) in August 1951 for the various age groups of rainbow and brook trout respectively were: age group 0, 2.1 and 2.9; age group I, 5.5 and 6.1; and age group II, 8.6 and 8.8.

9. On the basis of the four study sections there were an estimated 5,867 young of the year per mile of the study section in late fall (October-November) 1950 and 5,468 per mile in August 1951. A collection of brook trout made during their spawning season showed: (1) some young-of-the-year males were ripe, (2) the youngest ripe females were yearlings, (3) at least 72 per cent of the fish over 6 inches long were males.

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REVIEWS

Freshwater Fishery Biology. By Karl F. Lagler. Wm. C. Brown Company, Dubuque, Iowa. V-X: 360 pp. Appendix A-D. Sept. 15, 1952. $5.75.

This book is a natural successor to Dr. Lagler's "Studies in Freshwater Fishery Biology", published in 1949. While the new book contains much of the material that appeared in the earlier publication, the present volume is much more complete and workmanlike. Further, it is much more usable since it is published in an attractive case in regular book form which should stand up under hard usage by students.

A glance at the Table of Contents indicates there are 25 chapters, totaling 301 pages with the remaining 59 pages being devoted to appendices. The separate chapters cover the usual concerns of fishery biologists and bring together within the pages of a single book much of the material used in fishery management techniques today. Titles of the chapters are: I, Natural History and Ecology; II, Freshwater Fishes of North America, North of Mexico; III, Identification of Fishes and Other Aquatic Organisms; IV, The Literature of Fish and Fisheries; V, Fish Anatomy; VI, Fish Embryology; VII, Life History Stages Following Hatching; VIII, Food Habits; IX, Age and Growth; X, Age and Growth (Continued); XI, Length-Weight Relationship and Condition; XII, Fish Populations; XIII, Yield Analysis; XIV, Fish Pathology; XV, Pollution; XVI, Laws; XVII, Fish Culture; XVIII, Fishery Survey of Lakes, Ponds, and Impoundments; XIX, Fishery Surveys of Lakes, Ponds, and Impoundments (Continued); XX, Improvement of Lakes, Ponds, and Impoundments; XXI, Stream Surveys; XXII, Stream Improvement; XXIII, Creation of New Fishing Waters; XXIV, Freshwater Commercial Fisheries; XXV, Freshwater Recreational Fisheries.

In Chapter II, pages 21 to 36 inclusive cover a table entitled, "Checklist and Economic Classification of Common and Representative Freshwater Fishes of North America, North of Mexico." The economic classifications are based on the following categories: Sport, Commercial, Fine Food, Coarse Food, Forage, or Other. It seems to this reviewer that these 15 pages could have been better devoted to other matters or the material should have been con-

densed materially. The format used by the printer in setting up the table wastes much space. Another criticism of this table is that not all western fishes are listed which might well have been mentioned such as the common western minnows in the genera *Siphateles* and *Hesperoleucus*. In addition several important suckers and minnows present in the Lahontan Basin in enormous numbers could have been included.

The splittail, *Pogonichthys macrolepidotus*, is listed as being both commercial and coarse food. So far as this writer is aware, the splittail is not caught and sold commercially nowadays in California. The edible qualities of many fishes are often determined more by the method of preparation than the nature of the flesh. From the standpoint of Pacific and Lahontan Basin fishes, the table could have been greatly improved.

In Chapter XXI, "Stream Surveys," he has followed the late Dr. G. C. Embody to a considerable extent. On p. 268, Embody's trout stocking table for streams is given almost in the same form as it was first published in 1927. The pool grades (shelter) and food grades upon which the numbers of trout to be stocked in relation to stream width are practically identical with Embody's. It is surprising that after some 25 years of experimental trout planting and survival studies by many workers, Dr. Embody's table is still presented today in its original form. Embody himself said in his 1927 paper that, "These values (those presented in his stocking table) are tentative and subject to revision as further investigations reveal the true status of the factors concerned." We know now that bottom foods may fluctuate widely from year to year in abundance; that survival rates of small trout are on the whole negligible; that survival is better in lakes, and highest with 6–10 inch fish planted during the fishing season; that flood and drought may drastically modify basic stream conditions from year to year and season to season. Work on bottom foods in western streams has indicated enormous amounts present in some streams such as the Klamath and Rogue on the coast or the Owens and the Truckee rivers draining eastward from the Sierra Nevada Mountains. The food grades of 1, 2 and 3 are simply inadequate for application on a national scale and the writer would have liked to have seen a more critical review of the whole stocking problem than is given by Dr. Lagler. In fairness it should be stated that Lagler says that, "Stocking is no longer regarded as the principal means for maintaining and improving fishing . . ." and again that it, "has been shown at times to be unnecessary, wasteful, and even harmful", (p. 178). But a broad, critical approach to the problem, well documented, is lacking. If Dr. Embody were alive today he would, I am sure, have given us revised tables, well grounded on more recent studies.

The book on p. 258, cites Welch, 1948, for the Surber stream bottom food sampler but the first description of this net was published by Eugene Surber in 1937 and thus the reference should have been to Surber, not to Welch.

A number of the chapters are quite brief; in fact too brief to afford much real substance to the reader. The discussion of "Fish Culture" given in Chapter XVII is superficial and so highly condensed as to detract rather than add to the book. Similarly, Chapter XVI, "Laws," covers precisely two and one-half pages and might better have been omitted entirely.

Appendix A gives 36 halftone figures of scales of common families of American freshwater fishes. These are, for the most part, clean, clear and well printed. Also included in the Appendix are blank forms for use in fishery surveys, abbreviations for words used in the names of technical journals and periodic publications, a table on fish diseases and, lastly, temperature conversion tables from centigrade to Fahrenheit, inches to millimeters, eighths of an inch to millimeters, decimal equivalents, and ounces to grams.

The book is essentially concerned with techniques and methods rather than life histories and habits of any given fish or group of fishes. It is a "what to do" and "how to do it" book. For instance, in the index following the name, "brook trout" four page numbers are listed. Two of these refer to figures, one covering its anatomy (Fig. 9), and the other figures a scale (Fig. 142). The other two page numbers refer to two brief references to brook trout, one where the copepod parasite, *Salmincola edwardsii*, is noted as being specific for brook trout (p. 156) and the other where the use of brook, brown or rainbow trout for stocking

small ponds is considered (p. 273). This instance is cited merely to indicate the scarcity of life history or ecological materials in the book.

One of the strongest aspects of Dr. Lagler's book is the fact that he gives an excellent series of references at the conclusion of each chapter. While lack of space obviously prevented inclusion of many desirable items, nevertheless, the author has done an excellent job of selecting the references given.

The book is well illustrated with both zinc cuts and halftones. Some of his best pictures are concerned with standard field equipment used by fisheries biologists, including such items as nets, chemical equipment, dredges, current meter and scale projection apparatus.

As an introductory text for beginning students, the book will prove to be of great value in their training programs and at the same time provide a ready source of reference and techniques to be used as they are required. —PAUL R. NEEDHAM.

Hediger, H. 1951, Jagdzoologie — auch für Nichtjäger. Verlag Friedrich Reinhardt A. G. Basel. 212 pp., illustr.

According to the author, who is one of the best known European zoologists and students of animal behavior, the book was written to make hunters aware of their responsibility as guardians of game. Most likely the author will succeed. The book consists of a number of chapters on different mammals of Switzerland, written, like other Hediger publications, in a most fascinating manner. Peculiarities of behavior, life history and physiology of the mammals are recited and illustrated by many, probably original, observations and anecdotes on wild and captive animals. The book is a mine of information on Swiss game animals. A good proportion of the animals we read about have been extirpated in the past in Switzerland, many of them after having been hunted for alleged magical healing properties, (the beaver in addition for feeding on fish). Others like the otter are endangered at present. The book has a short bibliography.—HERBERT W. LEVI.

Grundlagen moderner Jagdwirtschaft (General principles of modern game management) by Dr. D. Müller-Using. Krögers Verlagsanstalt, Hamburg, Blankenese. 152 pp. 1949. DM 5.60.

Game statistics are the strength of European wildlife research. Carefully kept shooting statistics from Royal domains and feudal estates date in some cases back to the time when the first pioneers entered the American wilderness. The value of such statistics is manifold; they provide comparable figures for long periods of time, showing ups and downs in game populations; they indicate general increase and decrease of species; and they provide data for an evaluation of shooting, from an economic as well as a recreational point-of-view.

Müller-Using's recent contribution on German game statistics and their application in modern wildlife management and administration is a little goldmine of data on game numbers and should prove of interest to wildlife biologists and administrators in general.

The first part of this book contains a short, valuable survey of the development of hunting in Germany; legislative aspects of different types of shooting systems and some general considerations about definition of shooting, and volume and importance of this sport. The section on the development of the German hunting system and its tradition, extending through feudal times to post-war days, should give a good historical background for any outside reader unfamiliar with the reasons for a system of hunting which is characteristic of Europe in general.

The second part of this work is of most interest to the biologist; it is on game statistics as the basis for management practices. The major German game species are discussed in fair detail, and whereas the official "Reichjagdstatistik", the game statistics for the third Reich from 1935–39 is the nucleus of this treatment, older statistics from provinces, state forests and private estates are also incorporated.

As an example of the material presented, the following short review of the red deer data is given. The annual kill of red deer in Germany averaged 54,800, of which 19,500 were stags and 35,300 were hinds and fawns. Material from five different sources, totalling records on 88,260 deer, showed a fawn percentage varying between 20 and 29 per cent of the total fall

population (based on kill). It is considered that young deer of the year (both sexes) formed about 24.5 per cent of the total fall population. Stags made up 35.5 per cent. Of the remaining 40 per cent hinds, 25 per cent were old hinds and 15 per cent "Schmaltiere", i.e. maiden hinds.

Detailed deer weights from various parts of Germany are presented; also a table showing weight increase for stags and hinds for a ten-year period; stags in Westphalia increase in weight from 56.9 kg. in their first year to 115.4 kg. in their ninth year.

Sex and age composition in fallow deer was: bucks 34 per cent, old hinds 25 per cent, maiden does 11 per cent, and fawns 30 per cent. In the roe deer there were 45 per cent bucks, 35 per cent does and 20 per cent fawns. In the wild boar the sex and age composition was as follows: boars 20 per cent, sows 15 per cent, young 65 per cent. It is worth noting that while only 35 per cent of the fall population of the wild boar is old, no less than 60–70 per cent of the deer population is old; this difference is caused by the much higher breeding potential of the boar.

The German pheasant management plan may also prove of interest. The annual production of young per hen is figured at 3.5. The desired sex ratio on the shooting area is 1 cock per 5 hens, which ratio is aimed at during the open season. A winter reserve amounting to 10–20 per cent of the desired spring population is left to make up for accidental kills during the fall and winter in addition to the desired spring population. Hens may be killed and are killed in considerable numbers. About one million pheasants are shot in Germany per year.

The total production per year of edible game in Germany is 28,248,000 kg. to which is added about 1,500,000 kg. (heart, liver, etc.) of deer and about 10,000 kg. gulls' eggs, so that the annual production is about 30,000,000 kg. This means that the German people can cover their protein requirements from bagged game for about three days! According to weight hares made up 30 per cent of the total; roe deer 27 per cent; rabbits 14 per cent; red deer 13 per cent; wild boar 5 per cent, and pheasants 4 per cent. The total annual value of the major game birds and mammals amounted to 28,787,000 RM. The annual value of furbearers was 8,266,000 RM. The total annual value of game and furbearers was about 40,000,000 RM.

About 43,000,000 hectares of Germany's total area are considered shooting ground. Shooting rights are leased, and the average rental was 93 Pfennig per hectar or about 40,000,000 RM per year for the whole country, a figure in practice apparently corresponding to the value of the game taken.

In a final chapter is given a short survey of game statistics in other European countries. This is the weakest part of the book. It seems to have been written haphazardly; the very detailed official game statistics of, for example, the Danish and Finnish game departments are not mentioned at all, whereas a series of moose kill figures from Sweden is included.

Aside from such minor criticism, Müller-Using's book is a valuable compilation of data on game numbers. One of the aims with the book seems to have been to impress upon the occupying powers the economic as well as nutritional value of German game so as to help furthering the rebirth of hunting in Germany (hunting was then forbidden in Germany). Quite aside from this tendency in the book, it is a valuable addition to any wildlife library as it summarizes a vast collection of detailed game statistics.—KAJ WESTERSKOV, *N. Z. Wildlife Service, Department of Internal Affairs, Wellington, New Zealand.*

Tatalgewichts - Studien bei Norwegischen Vogelarten (Total weight studies of Norwegian birds). By Yngvar Hagen, Archiv für Naturgeschichte, N.F.Bd.11, Heft 1 - 2, 1942 pp. 1 - 173.

Among the few published studies on bird weights this comprehensive treatise on the weights of Norwegian birds deserves attention from wildlife biologists in general as probably no other paper published so far provides such a fund of data. The work was published during the last war and is as the title indicates printed in German.

After an introduction on the general value of weight studies in biological research a detailed account is given of applied techniques and problems connected with bird weight studies. Hagen proposes the term *total weight* to be used and defines total weight as the weight of the live individual with its total con-

tents of foreign matters contained in its organs (e.g. in crop, gizzard, intestine, oviduct, etc.). The fat condition of all examined material was determined according to the following scale: (fat) +4, +3, +2, +1, (Normal) 0, (Lean) −1, −2, and −3. By this method a condition factor for birds was accomplished. The *ideal weight* is the weight of the bird proper without any material in crop, gizzard, etc.

The average weight of a species in normal condition is $\frac{\Sigma \text{ Total weight}}{n'}$ where n′ is the number of weighed birds in normal condition.

Hagen weighed and examined personally 1300 adult birds; the total number of birds included in this study is 3144, belonging to 123 Norwegian bird species. Weights for a few of the larger birds, which also are found in North America are listed below, weight variation, average weight and number of birds weighed (n) being shown.

Raven (*Corvus c. corax*), 990–**1182**–1287 g. (6).

Magpie (*Pica p. pica*), 195–222 g. (2).

Short-eared owl (*Asio f. flammeus*), 303–**371**–505 g. (11).

Willow ptarmigan (*Lagopus l. lagopus*). This species is the national Norwegian game bird and Hagen has himself 1,487 ptarmigan weights. The extensive data are treated according to locality. The seasonal changes in weights in the two sexes of ptarmigan are also shown; the hen reaches a maximum (593 g.) mid-May, and a minimum (473 g.) in July. Males average 584 g. (405–750 g.); females 517 g. (405–680 g.).

The last chapters of this interesting paper discuss the following general topics: weight relationships between closely related species; sexual weight relationships; individual variations of the total weight; the lower limit of bird weights (as a general rule is given that when a bird's weight is down to about 50 per cent of normal, death usually occurs); adjustment of owls and falcons to fluctuating food conditions (females are better adapted to store food reserves than the smaller males); weight variations according to age; weight variations according to season (winter weights seem to be better than generally believed; thus may be mentioned that average weights and fat condition of owls and larger birds-of-prey are at maximal heights in the middle of winter); geographical variation of average weights; and weight variations from year to year and over longer periods (a slight but continuous decline in weights of willow ptarmigan was shown for the period of 1916 to 1934).

Especially the detailed treatment of the weight conditions of the great horned owl (*Bubo b. bubo*), goshawk (*Accipiter g. gentilis*) and willow ptarmigan (*Lagopus l. lagopus*) will be of interest and value to wildlife biologists. It is important to have proof that the fat condition of the great horned owl improves during late fall-early winter, the average weight increasing gradually from 2,178 g. (October) to 2,922 g. (January). In the goshawk Hagen shows a relationship between size of prey and sex of hawk, males averaging only 61 per cent of female weights.

Any student of bird weights who masters the German language should acquaint himself with this important paper for basic information, inspiration and new ideas. A comprehensive list of references gives a good introduction to the European literature on bird weights.—KAJ WESTERSKOV, *N. Z. Wildlife Service, Department of Internal Affairs, Wellington, New Zealand.*

BRIEFER ARTICLES

PRUNING AS A MEANS OF THICKENING MULTIFLORA ROSE HEDGES[1]

Thomas S. Baskett

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The rapid expansion of the multiflora rose planting program by action agencies makes pertinent observations on responses of the plant to treatments received in the field. Undoubtedly, many of those working with the rose have noted recovery after mowing, but data showing whether pruning results in thickening of multiflora hedges have not been published. The experiments herein reported were designed to furnish such data; all were carried out on the Ashland Wildlife Experimental Area in Boone County, central Missouri. The hedges were on Weldon silt loam, a light brown soil of low productivity (Scrivener and Frieze, Soils of Boone County, Univ. of Mo. Coll. Agr. Prog. Rpt. 14, 11 pp., 1951). The roses had been planted at 18-inch intervals.

The pilot experiment was intended to test the effects of hand-pruning at different heights. Dormancy had just been broken in the second growing season for the hedge when it was pruned. Prunings at heights of 4 inches, 14 inches and 30 inches were performed in two series; one unpruned strip was left in each series as a control.

Observations during the first fall indicated that pruning at the 14-inch level was best. In the second fall all live canes and primary branches intersecting a horizontal line 10 inches above the ground were counted. The results, shown in Table 1, bore out the earlier indication that pruning at 14 inches accomplished the greatest thickening. Pruning at four inches resulted in no appreciable thickening and in slow recovery.

TABLE 1.—STEM COUNTS IN TWO SERIES OF STRIPS PRUNED AT VARIOUS HEIGHTS

Treatment	Total Stems per 26 Feet of Strip
Pruned at 4 inches	292
Pruned at 14 inches	404
Pruned at 30 inches	362
Not Pruned (control)	288

In a second experiment, a year-old hedge, 1005 feet long, was staked out in 18 strips of equal length. Every other strip was pruned with a horse-drawn mower, the bar being set at a height of approximately 10 inches. Mowing was done when the plants were beginning to leaf out. The alternating nine strips were left unmowed as controls. After one growing season, stem counts of these strips were made at six inches above the ground. Results are shown in Table 2.

TABLE 2.—COMPARISON OF STEM COUNTS IN UNMOWED STRIPS AND STRIPS MOWED AT 10 INCHES

Unmowed Strips	Stems per 50 Feet	Mowed Strips	Stems per 50 Feet
A	618	B	688
C	644	D	652
E	601	F	682
G	492	H	712
I	581	J	718
K	562	L	785
M	455	N	638
O	713	P	762
Q	644	R	881
Totals	5,310		6,518
Means	590.0		724.2

The strips were lettered consecutively, strip B lying between strips A and C, etc. In every

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating. The writer is indebted to Dr. Robert Livingston, now of the Department of Botany, University of Massachusetts, and to Dr. William H. Elder for advice. Messers. Dean Murphy, John Lewis, Yuell Willis, and Perry C. Smith, aided in the field work.

case except one (compare strips N and O), the stem counts in the mowed strips exceeded those in the adjacent unmowed strips. The total counts show 22.7 per cent more stems in mowed than in unmowed strips.

Although the stem counts are difficult to make with accuracy, they certainly serve for comparison. The differences in the two sets of counts are statistically significant at the one per cent level ($t = 3.672$). Moreover, the differences in stem densities of adjacent strips were often clearly visible, even upon superficial examination.

In the final experiment, a 215-foot strip of three-year old hedge was pruned by hand at a height of 14 inches while the plants were dormant; stem counts were made at a height of eight inches. Stems were also counted in an adjacent unpruned control strip, 200 feet in length. Recounting of these pruned and unpruned strips were performed after one growing season. The counts, presented in Table 3,

TABLE 3.—RESULTS OF PRUNING THREE-YEAR OLD ROSE HEDGE AT 14 INCHES

Strips	Stems per 200 Feet at Time of Mowing	Stems per 200 Feet after One Growing Season	Per Cent Increase During One Growing Season
Pruned.....	1731	2273	31.3
Unpruned...	1635	1635	0

show that initial stem densities in the two strips were similar, and that pruning resulted in a 31 per cent increase in stem density during one growing season.

The presence of a few young canes in the unpruned strip indicated slight thickening during the course of the experiment, but counts were not accurate enough to reflect this difference. At the completion of the experiment, the difference in density of the two strips was quite visible.

In all three experiments it was evident that the sections of hedge pruned at 10 to 14 inches above ground did not "catch up" in height with the unpruned control strips during the first growing season. In some cases, the disparity was as great as two feet. However, in the second year the difference was obliterated, and the strips usually could not be distinguished by height. The pruned hedges produced almost no fruit during the first year, but superficial examination during the second winter revealed no obvious differences in fruit production of pruned and unpruned hedges.

In sections of pruned hedge, the increase in stem density contributed to the closure of gaps, but did not always complete the closure. In the unpruned section of the hedge used for the second experiment, 14 gaps probably large enough to admit a 30–40 pound pig were counted during the second winter after mowing. The comparable figure for the pruned section was six.

These experiments lead to the conclusion that mowing vigorous young rose hedges at heights of 10–14 inches during the dormant period results in desirable thickening, at least in a region where the rose is not subjected to repeated and severe winter injury. Other conditions, such as poor sites and poor early cultural treatment which affect growth and survival of rose plantings (see Klimstra, Some factors affecting growth and survival of multiflora rose as cover for quail in Davis County, Iowa. Jour. Wildl. Mgt., **15**: 158–160, 1951.) might lessen the value of mowing, for observations made during these experiments indicated that the vigorous portions of the hedges benefited most by pruning.

In field practice, mowing a year-old hedge can easily be accomplished with conventional farm mowing equipment if the bar is set high. Mowing probably should not be encouraged for very unthrifty hedges, and it will not close major gaps which need replanting. But mowing does hold promise of aiding in the closure of small gaps and of making the hedge stockproof. Apparently the only deleterious effects upon wildlife are in the first year after mowing, when nesting sites for songbirds are reduced and fruit production is greatly curtailed.

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AIDS FOR THE EXPLORATION OF THE AVIAN CLOACA FOR CHARACTERS OF SEX AND AGE

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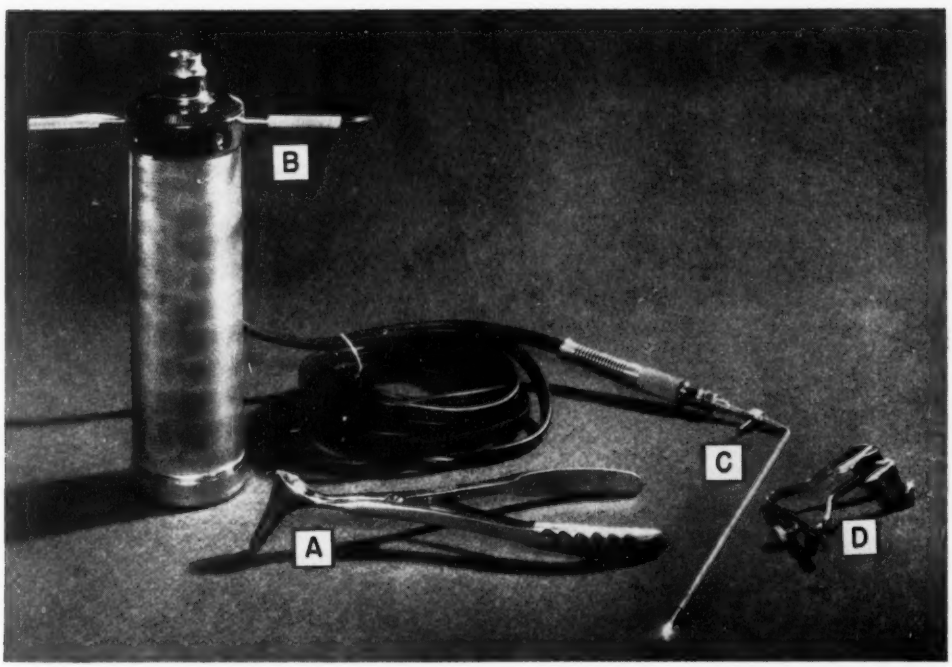
Progress in research is dependent on development of better tools which afford greater precision in the gathering of data. Better tools are especially needed in the game research profession which, in some respects, has lagged in the use of tools developed by older sciences. With these thoughts in mind, the writer suggests the use of several instruments developed by the medical profession, for the examination of the avian cloaca for characters of sex and age.

Birds whose sex or age is not readily distinguished by their outward appearance, may often be easily identified by cloacal characters. The anatomical features of the cloaca that are useful criteria of age and sex have been discussed by Hochbaum (1942), Elder (1946) and Hanson (1949).

For the examination of the cloaca of most waterfowl an adult-sized physician's nasal speculum was found to be useful, although it is too large for use on small birds. Confronted with the problem of examining the cloaca of mourning doves for sex and age characters, the writer in 1949 tried a Welch and Allyn otoscope with the realization that adequate lighting represents a problem in the examination of the cloaca in small birds. An otoscope, however, proved to be inadequate and difficult to insert in the living bird. It was found instead that a small infant-sized bi-valved nasal speculum like the Halle-Tieck type or a slightly larger size, was more useful, (Fig. 1A). The problem of adequate lighting in the examination of the cloaca in small birds, as well as in larger birds



Instruments used for examining the cloaca of birds: A, bi-valve nasal speculum; B, battery case of a Welch-Allyn otoscope; C, Jackson light carrier; D, Myles self-retaining type nasal speculum.

when the exterior light is poor, was solved by the use of a Jackson Light carrier, (Fig. 1C), an instrument normally used in conjunction with a bronchoscope. The power source for this light carrier is a Welch and Allyn otoscope battery case, (Fig. 1B), in which is incorporated a small rheostat, making it possible to regulate the brightness of the light bulb. As this light carrier is essentially a brass tube of about 2½ mm. diameter with a miniature light at the end, it serves admirably as a probe, especially for probing for the bursa and the oviducts in large birds (see Hanson, 1949, for illustrations on technique used). Some types of miniature bulbs used with this light carrier have pointed tips; hence it is suggested that in order to prevent injury to delicate tissues, a Pilling-Jackson lamp, which has a rounded tip, be used in conjunction with this instrument.

If prolonged inspection of the cloaca or some other investigative procedures are contemplated, the use of a Myles self-retaining type nasal speculum, (Fig. 1D), may have some advantages. This speculum would probably be most useful in birds whose cloacae had been anesthetized as it can be forced quite readily out of the cloaca of an untreated bird.

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SEX AND AGE CLASSES IN THE HUNGARIAN PARTRIDGE

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Inasmuch as the sex and age composition has never been published for any North American populations of Hungarian partridges (*Perdix perdix*), we wish to report the results of a small study carried out in Wisconsin in 1951.

The technique used was the familiar one of asking hunters to send in wings of birds they shot. In this case we also asked for scapular feathers, as a supplementary means of ascertaining sex. We are indebted to the Wisconsin Conservation Department for materials which provided us with a list of partridge hunters, and to the 191 sportsmen who courteously sent us the requisite feathers. We also received much help from students at the University of Wisconsin who assisted us in addressing questionnaires to hunters. The legal hunting season in this year began for Huns at 1:00 P.M. on October 13 and closed one hour before sunset on November 11.

A weekly breakdown of the hunting mortality is given in Table 1. From this tabulation, it is evident that one-third of the kill took

TABLE 1.—CHRONOLOGY OF THE HUNTING KILL BY WEEKS

Date	Juveniles ♂	Juveniles ♀	Juveniles Σ	Adults ♂	Adults ♀	Adults Σ	Unaged	Total All Age Classes
October 13–19	41	37	78	13	11	24	1 ♀	103
October 20–26	14	20	34	7	7	14	...	48
Oct. 27–Nov. 2	32	18	50	9	5	14	...	64
November 3–9	26	25	51	7	6	13	1 ♀	65
November 10–11	6	8	14	2	2	4	...	18
Totals	119	108	227	38	31	69	2 ♀	298
Per cent	52	48		55	45			

place in the first week. In our sample, 27 were shot on opening day and 33 on the second day of the hunting season. In general, this chronology follows that reported for other North American game birds. Our hunters were a selected group (those who shot 3 or more Huns in 1950) and perhaps they shot more on weekdays than the average sportsman.

A further breakdown of the sex and age distribution in this sample is given in Table 2. In general, the high percentage of juveniles follows that reported for bobwhite quail (*Colinus virginianus*) by various investigators and for Hungarian partridges in Denmark by Westerskov (Saertryk af Dansk Jagt, 5 May 1951, pp. 26–28). One should notice that the proportion of juveniles bagged in the first half of the season was not larger than in the second half. This suggests that juveniles were no more vulnerable to the gun than adults. This condition even holds for the opening week-end of the season where 61 birds were taken. Excluding one unaged female, 75 per cent of these were juvenile. The presence of 77 per cent juveniles in this Wisconsin sample is not significantly different from the 80.3 per cent reported in Denmark by Westerskov.

Our samples point to an even sex ratio among both juvenile and adult Hungarian partridges in Wisconsin. This follows expectation for juveniles but seems surprising to us for the adults. The size of the latter sample is very small, so that we attach no biological significance to this result.

Among the birds shot during the first 12 days of the hunting season, we attempted to work out a hatching curve taking the age of each bird according to Petrides' summary of Bureau's work (Jour. Wildl. Mgt., **15**(1): 116–117, 1951). During the first week of the hunting season, only one young bird had a completed molt. This increased to 7 out of 34 in the second week, and to 44 out of 50 in the third week. The results, given in Table 3, show a peak in the first week of July identical to that previously reported for southern Wisconsin by McCabe and Hawkins (Am. Midl. Nat., **36**(1): 1–75, 1946). The very rapid build-up of this calculated hatching curve in 1951 seems to us to be rather unusual, and we believe the result should be regarded with some caution, at least at present.

TABLE 3.—POSSIBLE HATCHING DATES FOR HUNGARIAN PARTRIDGES

Calculated Hatching Dates	Periods When Birds Were Shot: October 13–19	October 20–24	Totals
June 21–27 or earlier	1*	5*	6
June 21–27	22	..	22
June 28–July 4	33	9	42
July 5–11	4	7	11
July 12–18	2	2	4
July 19–25	5	0	5
July 26–August 1	3	2	5
August 2–8	4	1	5
August 9–15	..	..	..
August 16–23	..	1	1

* Birds with completed wing molt.

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TABLE 2.—SEX AND AGE COMPOSITION OF THE BIRDS BAGGED

Sample	Date Shot	Juvenile ♂	Juvenile ♀	Juvenile Σ	Adult ♂	Adult ♀	Adult Σ	Total	Per cent Juv.
First half of sample	Oct. 13–26 inclus.	55	57	112	20	18	38	150	75
Second half of sample	Oct. 27–Nov. 11	64	51	115	18	13	31	146	79
Totals		119	108	227	38	31	69	296	77
Per cent		52	48		55	45			

LIVE TRAPPING OF DIVING DUCKS[1]

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The trap and methods described here, though not completely new, have been particularly successful for diving ducks under Michigan conditions. Most of the little points on technique were acquired by experience rather than by reading about them. It is the lack of definite information in the literature on these points that has prompted the presentation of this paper. Kutz ("An Improved Game Bird Trap", Jour. Wildl. Mgt., 9(1): 35–38, 1945) offers a good review of the existing literature.

From early December to early May of the past several years, diving ducks have been live-trapped in considerable numbers in the lower Detroit River. Live trapping was carried on to study winter mortality factors and to obtain other information resulting from banding records. The following divers have been taken: canvasback, redhead, lesser and greater scaup, American goldeneye, and bufflehead.

After using various traps in the past ten years, a type has been evolved that is reasonably successful in the lower Detroit River where water levels fluctuate as much as two feet within six hours. This trap is simply a modification of the conventional lily-pad type (Figs. 1 and 2). The advantage of this shape is that it eliminates all corners where ducks can congregate and in trampling about cause mortality from suffocation and exhaustion.

The frame of the trap is made of 4½-foot, 11-gauge, weldwire fencing with a mesh of 2 x 6 inches. The greater number of wires should run vertically to provide support. Winter trapping necessitates use of 11-gauge wire

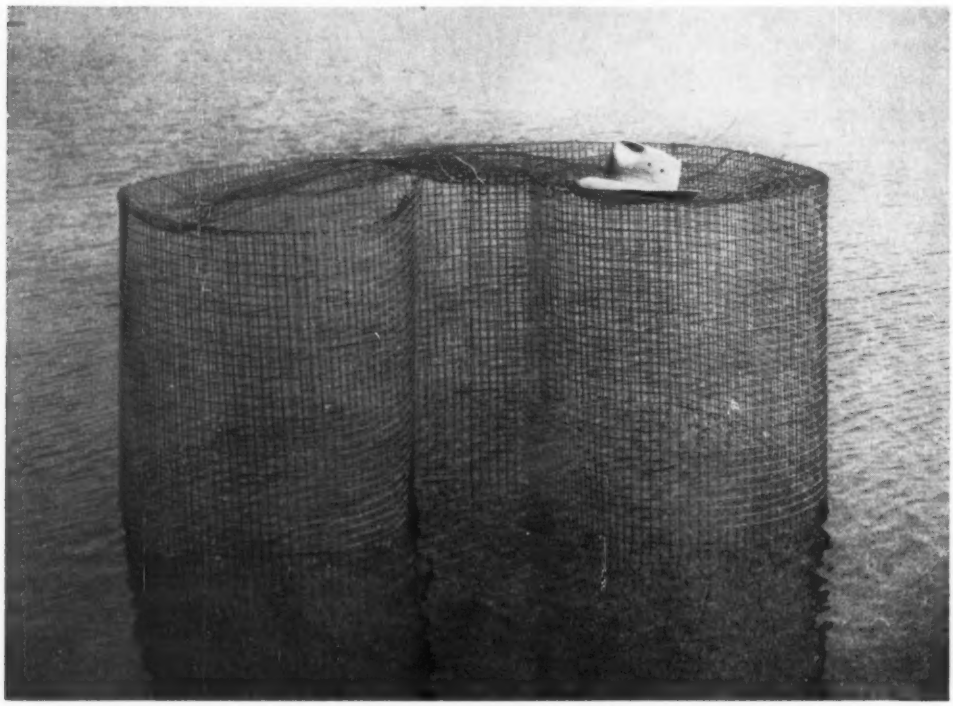

FIG. 1. Front view of diving duck trap.

[1] Contribution from Federal Aid in Wildlife Restoration Act Project, 45-R, Michigan.

in order to withstand the weight and removal of ice.

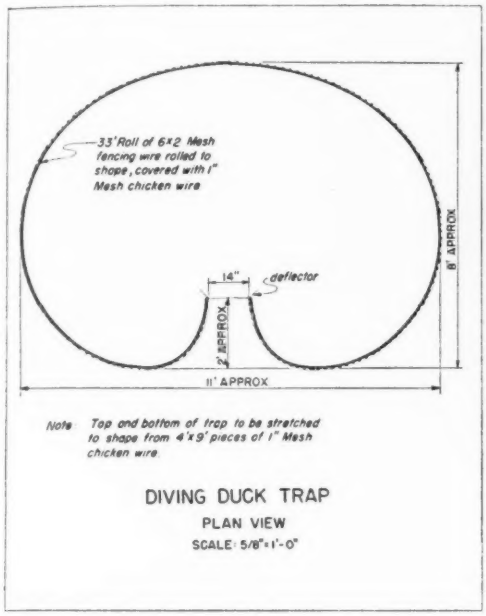
33' Roll of 6x2 Mesh fencing wire rolled to shape, covered with 1" Mesh chicken wire
14"
deflector
2' APPROX.
6' APPROX.
11' APPROX
Note: Top and bottom of trap to be stretched to shape from 4'x9' pieces of 1" Mesh chicken wire.
DIVING DUCK TRAP
PLAN VIEW
SCALE: 5/8"=1'-0"

FIG. 2. Plan view of diving duck trap.

To reduce mortality the fencing is lined with one-inch mesh poultry netting four feet high. The same type of poultry netting is used for the top and bottom of the trap. The six-inch discrepancy between the heights of the frame and netting allows an escape hole at the top of the throat in case water level fluctuation is so great that it would endanger the birds with drowning (Fig. 3).

A step-by-step description of trap construction follows. A piece, 30 feet long, of the heavy 4½-foot fencing is cut and laid flat on a working surface. Next, a piece of the 4-foot poultry netting 33 feet long is cut and laid on the fencing with ends of the netting extending 18 inches past each end of the fencing and with the bottom edges even. This netting is then hog-ringed to the fencing at one foot intervals both lengthwise and crosswise. Such a close bond of the netting and fencing is necessary to withstand the beating in ice removal. Next, the trap is set upright and curved to the lily-pad shape.

FIG. 3. Escape hatch for ducks during high water level.

The curve of the trap making the throat must be a shallow one and the throat width no less than 14 inches. The two ends of poultry netting that extend 18 inches past the heavy fencing in the throat must each have a square 14 x 14 inches cut from the lower corner. This leaves 4 inches of netting extending past the end of the fencing on the bottom portion. The two top 18-inch extensions are overlapped and fastened together with lacing wire. Then, the two 4-inch extensions of netting remaining at the bottom of the trap are each curved outward at a 45° angle inside the trap to deflect ducks from the opening as they swim about inside the trap (Fig. 4). Next, a bottom of one-inch mesh poultry netting is placed on the trap. The bottom netting, the bottom edge of the side netting, and the bottom edge of the fencing frame are laced securely together. The trap is turned over and a top of one-inch mesh poultry netting is laced to the top edge of the fencing frame. The bottom and top are trimmed to fit the trap shape after lacing. A five-foot portion of the top at the rear of the trap is temporarily laced with galvanized stove wire and can be undone to dip the birds from the trap with a long-handled net.

Selection of a proper trapping site is essential for successful trapping of diving ducks. A site

should be selected where protection from prevailing winds is available, and where the bottom of the body of water is of hard sand, small gravel, or firm clay. Such a bottom makes the bait more available and prevents undermining of the trap by feeding ducks. It is important not to place the trap in a site where swift water currents will wash the bait from the trap, nor should there be a lack of current because the trap will be too easily frozen in. The site should be as far from shore as possible since divers generally do not like to feed near shore. A normal water level of about 34 inches should prevail at the site, thus allowing a drop of 20 inches before the throat opening would be exposed and a 20-inch rise before the trap would be submerged.

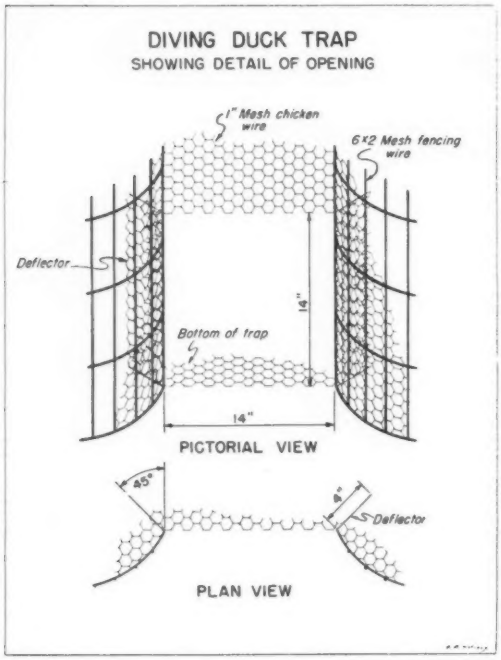

FIG. 4. Detail of opening.

After the site has been chosen, the feeding of grain is essential to lure the birds to that spot. This baiting should be continued until a goodly number of ducks have found the feed; then, a lapse of a day allowed for excess bait to be taken by the ducks after which a trap may be set, or, a group of several traps, if there is room on the site. If a group is used, about six feet between traps should be allowed for the passage of debris, small cakes of ice, etc. The trap should be set with the throat facing down stream in the case of a river or away from shore in the case of a lake since divers feed upstream and inshore.

The trap is now set and baited, preferably with wheat, since the small kernel makes necessary more trips by each diver to the trap than would a large grain. Wheat is heavier than barley or rye and not liable to be washed out of the trap. One 10-quart pail of wheat is poured from the top just inside the trap at the opening, care being taken to deposit the grain far enough back of the opening that the wheat settles in the proper place. A few handfuls of wheat should be thrown into the throat outside the trap and a few handfuls sown within 20 feet in front of the trap.

At this station the ducks are usually taken from the traps shortly after dawn, again about noon and again shortly before dark. This will depend on how rapidly the birds are going into the traps and on the weather.

The trap is approached from the throat and a plug thrust upright into the opening to prevent escape of the ducks (Fig. 5). The use of such a plug eliminates bending the throat wires to close the opening and subsequent raising of the trap to reset the opening properly. The trap bottom must be flat on the stream or lake bottom so no obstruction prevents ducks from entering. When a group of traps is used all openings must be plugged upon arrival, else birds will escape from traps not closed. Diving ducks must be taken from the traps as rapidly as possible to prevent exhaustion from continuous diving. Using open-weave burlap bags to transport ducks from trap to banding station results in quieter birds and easier handling than does the use of wood crates.

Modifications of this trap can be made by varying the size and other details to meet differing field conditions. Our experience has shown this trap to be excellent because it is portable and results in the capture of many divers. During the winters of 1949–51 some 25,000 ducks have been taken at this station.

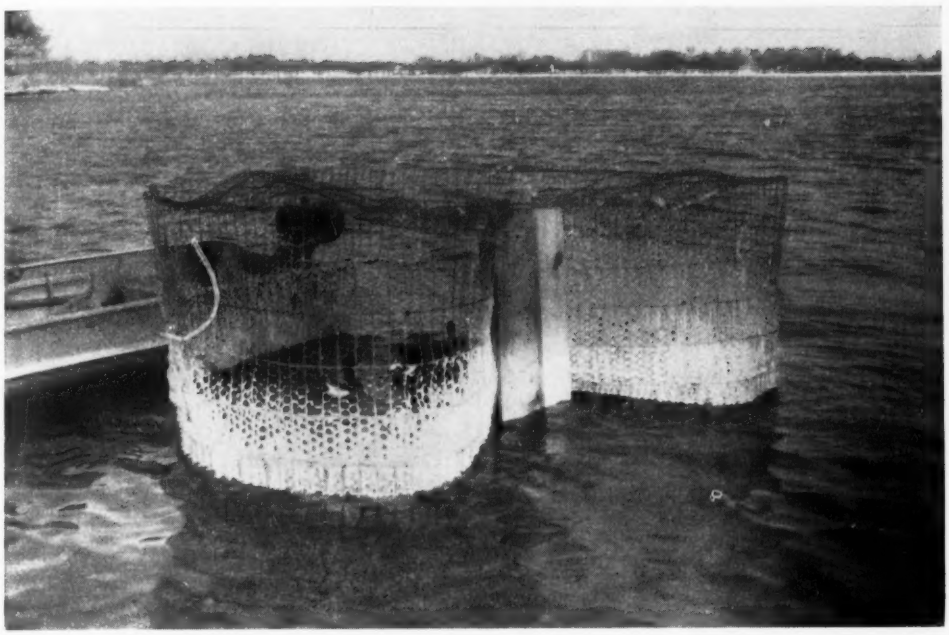

FIG. 5. Showing throat closure board to prevent escape while removing ducks from trap.

The authors wish to express their gratitude for technical assistance to H. J. Miller of the Game Division, Michigan Department of Conservation, who developed an earlier version of the present trap.

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THE SECONDARY SEX RATIO IN *ODOCOILEUS*[1]

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The secondary sex ratio or sex ratio at birth is an important characteristic of any animal population. A knowledge of its approximate value is of great utility wherever sex ratios are used in analyzing population dynamics. The secondary sex ratio can be determined in fetuses from pregnant females, if abortion is not important, or directly in newborn young.

In the genus *Odocoileus*, determination of the secondary sex ratio by examination of fetuses is valid only in the latter half of pregnancy when abortion is negligible. Determination of the secondary sex ratio from fawns at birth is practicable only where the deer are penned. Counts after the fawn drop may not yield valid data, differential mortality may occur between birth and count.

Observations on the secondary sex ratio of the white-tail (*O. virginianus*) and the Rocky Mountain mule deer (*O. h. hemionus*) have been made by various authors. To these findings I have added hitherto unpublished material on the Rocky Mountain mule deer and the Columbian black-tailed deer (*O. hemionus columbianus*) in the tabulation below.

These records have been grouped taxonomically and subjected to statistical analysis. The

[1] Contribution from P-R Project 31-R-5: The effects of brush removal on game ranges in California.

TABLE 1.—SUMMARY OF OBSERVATIONS ON THE SECONDARY SEX RATIO IN *Odocoileus*

Authority	Species	Number of males	Number of females	Males per 100 females
Chattin	*O. h. hemionus*	34	30	113
Robinette & Gashwiler	"	171	136	129
Robinette (letter)	"	29	26	112
Nichol	"	6	5	120
* Bischoff (Doyle Herd)	"	9	14	64
" (Truckee Herd)	"	20	10	200
" (Inyo Herd)	*O. h. inyoensis*	38	20	190
" (Tehama Herd)	*O. h. columbianus*	12	15	80
" (Siskiyou Herd)	"	19	17	112
Taber	"	28	22	127
Shaw & McLaughlin	*O. virginianus borealis*	40	34	118
Cheatum & Morton	"	9	11	82
Haugen & Davenport	*O. virginianus* ssp.	17	12	142
Illige	*O. v. texanus*	19	14	136
	Total	451	366	

* Unpublished data from California P-R Project 35-R: A study of diseases of wildlife species in California.

results are presented in Table 2, where the figures in parentheses represent the spread within which the mean would fall in 95 percent of the cases.

It is evident that the general tendency is for the males to outnumber the females by from ten to twenty percent. In the single subspecies for which a fairly large sample is available (*O. h. hemionus*) it may definitely be stated that the males outnumber the females at birth. For *O. h. columbianus* and *O. virginianus* the samples are not yet large enough to demonstrate conclusively an unbalanced secondary sex ratio, but the weight of evidence is in that direction.

It is well known that in many mammals there is a preponderance of males at birth. In the domestic cow and pig, and to a lesser degree the domestic sheep, the fetal sex ratio, the sex ratio of stillbirths and abortions and the sex ratio at birth all show a preponderance of males. In the animals in which these matters have been most closely studied it is sometimes assumed that an extrapolation may be made along the changing curve of sex ratios to give the sex ratio at conception, which is thus thought to be quite heavily in favor of males. However, the mechanism controlling the determination of sex at conception is not yet completely understood (Asdell 1946).

Reports on the extent of prenatal mortality in *Odocoileus* have been few. Robinette and Gashwiler (1950) found only three out of 318 fetuses, or 0.9 percent to be abortive. The present author has examined 50 fetuses without detecting signs of abnormality (Taber, 1953). Bischoff (*op. cit.*) in one collection, found one out of 105 fetuses, or about one percent to be abnormal. In a collection taken from another herd he found three out of 96, or over three percent to be abortive. This suggests that prenatal losses may at least occasionally be

TABLE 2.

Group	Number of males	Number of females	Males per 100 females (.05 level of accuracy)
All *Odocoileus* spp.	451	366	123 (107–141)
O. hemionus ssp.	366	295	124 (107–145)
O. h. hemionus	269	221	122 (102–146)
O. h. columbianus	59	54	109 (72–159)
O. virginianus ssp.	85	71	120 (89–165)

substantial. If such losses were heavier in males than in females, as has been found in livestock, it is evident that a deer population suffering a considerable abortion-rate might display a secondary sex ratio in which the sexes are equal, or even one in which the females outnumbered the males.

It appears that if in the course of studies on the population dynamics of some species of *Odocoileus* it became necessary to assume a secondary sex ratio, a value of 120 males to 100 females would probably be a good approximation. Further observations will undoubtedly refine this and marked deviations from it could lead to a more complete understanding of the factors which influence fetal survival.

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AERIAL DEER COUNTS

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There has been some discussion pro and con concerning the feasibility of counts of deer from the air. Although in open country the plane has been found of value in censusing deer (Blomquist, North Dakota Outdoors, April, 1951), it is generally considered that in wooded sections, aerial observations are of limited worth (Crissey, New York Fish & Wildlife Info. Bull. 4, 1949).

During the spring of 1950 in Robertson County, Texas, aerial deer observations were attempted with some success. In wooded areas which have some openings, flights at sundown may yield fairly consistent counts of deer seen in the open. The entire validity of such counts has not been determined but it is hoped that others may become interested in pursuing the matter further.

In the Seale Ranch area, known to contain deer, preliminary flights were made in order to become thoroughly familiar with landmarks. Such orientation was essential to maintaining a grid flight pattern despite frequent low-altitude circling. On the censuses, six strips were cruised parallel to one side of the oblong-shaped area. Altitudes of 300′–400′, or occasionally lower, were maintained, depending mainly on darkness. The first two strips were over open farmland, the third along a woods border and the last three over dense woods containing only about 10%–15% scattered openings. The area comprised about 11,000 acres about half of which was in crops and improved pasture. A Piper Cub (J-3 or PA-11) was used in these studies. Faster planes were somewhat less desirable. A wildlife student was carried as observer.

It was found that deer emerged from the

post oak forest, which was overbrowsed by deer and cattle, during spring evenings to graze on the new grass in the fields and openings. This emergence occurred almost precisely at official sundown when, in some areas, groups of deer could be seen to trail into open areas. Observations before official sundown yielded counts from zero to about half the expected number of deer, depending on the time of day. On June 8, for example, a cruise of the most productive three strips (see beyond) revealed 45 deer between 6:30 and 7:00 p.m. and 75 between 7:00 and 7:30 p.m. There usually was light enough for about an hour's flying time and return to the airport about six miles distant if the plane was over the area at sunset. Only clear and rather still evenings were chosen. Apparently satisfactory counts were procured from February until late May, when the fawning season evidently diminished observable deer numbers.

The following table provides the details of deer counts on six spring evenings. For the first five dates, the counts ranged between 118 and 144 deer, averaging 128 with a standard deviation of 10.6. Just what proportion of the total population was seen in the fields or what ingress or egress took place during the study period is unknown, but the relatively constant totals would seem to indicate a possible value for such counts at least as indicators of population trends. Very few deer could be seen in the woods even before the leaves appeared on the trees but those in fields were obvious even though bedded down.

Some observations also were made on the sizes of bands of deer and on sex and age ratios. As many as 25 deer fed and apparently moved about together in somewhat cohesive groups. Average band-sizes are given above. The first fawn was observed on May 20, about a month before they were reported from the ground by residents or students working on other wildlife problems on the area. Sex determination of deer was difficult from the air without making extremely low swoops over them, causing some dispersal of the feeding groups. Even as late as August 4, when antlers were fairly well grown, only five does and one buck of the 27 adult animals seen on the area could be identified as to sex. On that same date, however, 11 fawns were counted, only eight of which were associated with five does. It seemed apparent that adult: fawn ratios can be easily determined from the air, but that sex ratios can be better determined otherwise.

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Date	Average Group Size	Strip 1	Strip 2	Strip 3	Strip 4	Strip 5	Strip 6	Total
March 22....	6.0	0	0	34	33	39	27	133
April 17.....	4.1	0	4	71	9	3	39	126
April 26.....	8.4	0	6	66	3	29	14	118
May 15.....	4.7	0	0	1	42	50	51	144
May 20.....	3.8	..	4	34	10	18	54	120
June 8.....	3.8	..	0	1	12	31	32	76

AUTUMN COLORS, AN AID TO WILDLIFE COVER MAPPING[1]

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In type-mapping deciduous hardwood forests, limited application can be made of autumn colors. When adequate vantage points are accessible, brightly colored autumn foliage can be distinguished beyond the usual range of observation used in mapping summer foliage. With the aid of stereoscopic vision, aerial photographs can be used to locate points of vantage from which to view the terrain.

A typical example should serve to illustrate

[1] Contribution from Pittman - Robertson Project 21-R.

the use of autumn colors. Assume that the mapper is standing on the southern rim of an east-west valley, mapping the vegetation on the north slope. He has mapped the northern hardwoods, the most extensive type on the north slope, and now turns his attention to a hollow cutting into the slope. Whereas the northern hardwood type has been identified by its yellow to orange-red colors interspersed with the green of hemlocks, the foliage in the hollow is predominantly yellow. From previous experience he knows that the cover type is either cove hardwoods or hickory. The mapper examines the form of the trees with a binocular. If the crowns of the yellow-leaved trees are pyramidal in shape, the type is cove hardwoods. Should the trees have tall, straight trunks with small open crowns a hickory stand is indicated.

The predominant colors for particular species at the height of the autumnal season and supplemental aids, enabling identification of species are outlined in chart form (Table 1).

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TABLE 1.—IDENTIFICATION OF FOREST TYPES BY AUTUMN COLORS AND SUPPLEMENTAL CHARACTERISTICS

Forest Type and Species	Foliage Color at Height of Autumn	Supplemental Characteristics
Northern Hardwoods		
Sugar maple	Yellow to orange-red	Gray-white bark; opposite branching.
Black birch	Reddish-yellow	Smooth, black bark.
Yellow birch	Reddish-yellow	Golden gray to bronze-colored bark.
Beech	Tan to brown	Smooth, light gray bark.
Witch hazel	Yellow	
Hemlock	Green	
Cove Hardwoods		
Yellow poplar	Yellow	Pyramidal crowns.
Basswood	Yellow	Bark with narrow, somewhat scaly ridges, gray in color.
White Ash	Brownish-yellow	Opposite branching, somewhat open crown.
Greenbrier	Greenish-yellow	Green vines.
Scarlet Oak		
Scarlet oak	Scarlet	
Chestnut oak	Brownish-yellow with irregular green spots	
Hard pine	Green	
Blueberry	Mottled dark red and yellow	
Oak-Hickory		
Hickory	Yellow to brownish-yellow	Small, open crowns; tall, straight trunks.
Red oak	Yellowish-brown	Bark with smooth, flat ridges.
Scarlet oak	Scarlet	
Flowering dogwood	Purplish-red	
White Oak		
White oak	Purplish-red	Light ashy gray bark.
Flowering dogwood	Purplish-red	

CANINE TEETH IN WHITE-TAILED DEER

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Canine teeth in either the upper or lower jaw are not present normally in adult North American deer. Only two authors record definite examples of canines—Nordquist in two male mule deer in California (Calif. Fish and Game, **27**: 39, 1941) and Allen in three white-tailed deer from Mexico (Amer. Mus. Nat. Hist., Bull. 12, pp. 191-262, 1900). Recently a specimen of a white-tailed deer, with well developed upper canine teeth, was obtained at Rancho San Bartolo, on the Rio Cintalapa, Chiapas, Mexico. The presence of the canines in this specimen led us to examine skulls of deer in some collections.

In all, we have found 11 mature white-tailed deer, *Odocoileus virginianus*, with upper canine teeth, although we have examined not more than 325 skulls in collections of the American Museum, Chicago Natural History Museum, and our own. Three of these 11 were those reported by Allen (*op. cit.*).

Canine teeth must be present in deer only rarely, in spite of this ratio of about 1:30. In a study of some 900 skulls of white-tailed deer, R. M. Kellogg informs us (in *litt.*) that he recalls only one or two instances of canines observed by himself and E. A. Goldman. Canine teeth apparently are more prevalent in Central American specimens, for 6 of the 8 specimens from known localities are from south of the 24th parallel. Additional information on the presence of canine teeth in any North American deer, and their place of occurrence, would be of interest.

Editor's Note: William Severinghaus, leader of the New York State Conservation Department deer investigations, has indicated in response to inquiry, that a cursory check of the tooth data on approximately 18,000 New York deer examined during the investigation revealed at least 23 that had one or both canines. Since two-thirds of these deer were seen only in fresh condition at roadside checking stations, he suggests that in all probability some very small canines were overlooked.

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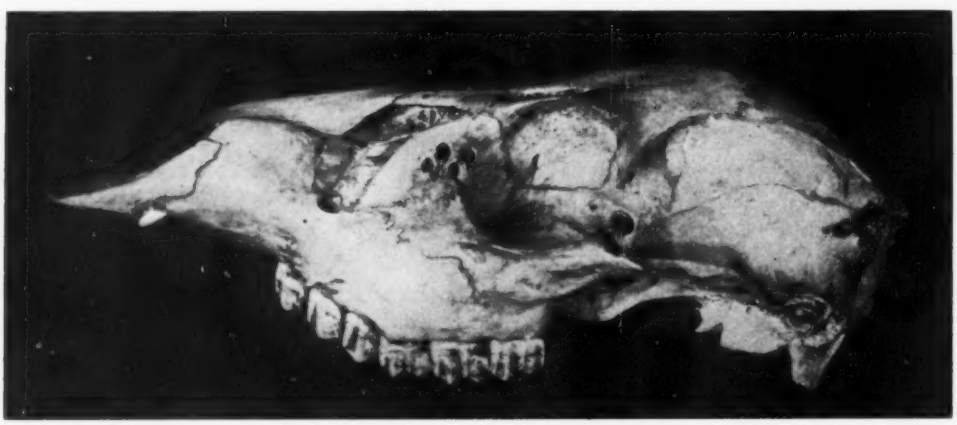

Fig. 1. Skull of female white-tailed deer, *Odocoileus virginianus nelsoni*, from Rancho San Bartolo, Chiapas, Mexico, showing upper canine tooth.